

Table 4-1 17. Positive detections of uranium-233/234 from perched water wells greater than 140ft deep.

Perched Water Well	Concentration \pm 1a (pCi/L) Water	Confirmation Flag	Concentration \pm 1a (pCi/g) Filtered Sediments	Confirmation Flag ^a	Date
USGS-92	6.9 \pm 1.9	A	0.47 \pm 0.05	A	April 1998
	7.5 \pm 0.6	A	0.35 \pm 0.03	A	December 1998
	2.2 \pm 0.4	D	0.66 \pm 0.08	A	March 1999
	2.5 \pm 0.7	D	—	—	March 1999
	3.0 \pm 0.7	D	0.75 \pm 0.13	D	November 1999
	2.3 \pm 0.7	D	0.90 \pm 0.14	D	November 1999
	6.7 \pm 0.7	A	0.76 \pm 0.07	A	March 2000
8802D	0.53 \pm 0.17	A	—	—	December 1998
	1.3 \pm 0.4	A	—	—	March 2000

a. Confirmation flag:

A = No second sample collected, no reanalysis performed.

D = Detection confirmed by reanalysis.

Note: Highlighted values and the "D" confirmation flag indicate a confirmed detection.

Note: Concentrations in red bold exceed the 1E-05 risk-based concentration for aquifer.

4.6.19.2.5.2 Uranium-235/236—A total of 21 water samples and six filtered sediment samples from the perched water wells and deep suction lysimeters were analyzed for U-235/236 between 1998 and December 2000. There were no positive detections identified. The USGS does not analyze perched water Well USGS-92 for U-235/236.

4.6.19.2.5.3 Uranium-238—A total of 21 water samples and six filtered sediment samples from the perched water wells and deep suction lysimeters were analyzed for U-238 between 1998 and December 2000, with 13 positive detections (see Table 4-118). None of the results exceed the 1E-05 aquifer risk-based concentration for U-238 (5.47 pCi/L), and none of the results in the 140+-ft region of the vadose zone are suspiciously high.

Table 4-1 18. Positive detections of uranium-238 from perched water Wells USGS-92 and USGS-8802D.

Perched Water Well	Concentration \pm 1a (pCi/L) Water	Confirmation Flag	Concentration \pm 1a (pCi/g) Filtered Sediments	Confirmation Flag ^a	Date
USGS-92	3.6 \pm 1.1	A	0.53 \pm 0.05	A	April 1998
	4.7 \pm 0.4	A	0.40 \pm 0.04	A	December 1998
	1.2 \pm 0.3	B	0.71 \pm 0.08	D	March 1999
	1.3 \pm 0.4	B	0.68 \pm 0.12	D	November 1999
	Not detected	—	0.88 \pm 0.14	—	November 1999
	2.2 \pm 0.4	A	0.72 \pm 0.07	A	March 2000
	0.37 \pm 0.11	D	Not applicable	—	March 2000
8802D	0.89 \pm 0.26	D	Not applicable	—	March 2000

a. Confirmation flag:

A = No second sample collected, no reanalysis performed.

D = Detection confirmed by analysis.

Note: Highlighted values and the "D" confirmation flags indicate a confirmed detection.

4.6.19.2.5.4 Uranium Ratios—Two perched water samples from the greater than 140-ft-depth interval of the vadose zone were sent to Los Alamos for TIMS analysis. The samples were filtered and both the filtrate and filtered material were analyzed for isotopic U-235, as well as

U-234, U-236, and U-238. The 8802D water sample results showed uranium isotopic ratios indicative of depleted uranium (Roback et al. 2000). This sample also contained U-236, which is indicative of anthropic uranium.

4.6.19.3 Aquifer

4.6.19.3.1 Uranium-233/234—A total of 162 aquifer samples in the vicinity of the RWMC were analyzed for U-233/234 between 1998 (beginning of uranium monitoring) and April 2001. All the wells sampled around the RWMC have detectable levels of U-233/234 at concentrations typical of background (1.1 pCi/L) uranium in aquifer. The U-233/234 results varied from 0.40 ± 0.04 pCi/L (M4D) to 1.84 ± 0.15 pCi/L (OW-2), with the majority of values between 0.82 and 1.54 pCi/L. The occurrence of U-233/234 detections in aquifer samples is shown in Figure 4-60.

The USGS does not analyze for U-233/234 in their eight RWMC wells they manage, control, and routinely sample.

The concentrations of U-233/234 detected are at background concentrations, and below the $1\text{E-}05$ aquifer risk-based concentration (6.63 to 6.74 pCi/L). Ninety-three of the samples slightly exceeded 1.1 pCi/L, but did not appear to be elevated above background concentration.

Some INEEL aquifer well samples were analyzed using the TIMS method with an ultra-low detection limit and computed uranium ratios. The results suggest that the uranium in the aquifer beneath the RWMC is naturally occurring (i.e., U-234) and that the aquifer has not been impacted by anthropic uranium.

4.6.19.3.2 Uranium-235/236—A total of 161 RWMC aquifer well samples were analyzed for U-235/236 between 1998 (beginning of uranium monitoring) and April 2001. All the wells sampled around the RWMC have sporadic detections of U-235/236 at concentrations near the detection sensitivity of the radioanalytical method. The U-235/236 detections varied from 0.020 ± 0.006 pCi/L (M15S) to 0.18 ± 0.02 pCi/L (OW-2), with the majority of values between 0.03 and 0.10 pCi/L. Figure 4-61 identifies the detected concentrations of U-235/236 in the aquifer. The USGS does not analyze for U-235/236 in their eight RWMC wells.

4.6.19.3.3 Uranium-238—A total of 162 RWMC aquifer well samples in the vicinity of the RWMC were analyzed for U-238 between 1998 (beginning of uranium monitoring) and April 2001, all with detectable levels of U-238 at concentrations typical of background uranium in the Snake River Plain Aquifer. The U-238 results varied from 0.21 ± 0.03 pCi/L (M4D) to 0.88 ± 0.08 pCi/L (OW-2), with the majority of values between 0.4 and 0.7 pCi/L. The USGS does not analyze for U-238 in the eight RWMC wells they manage, control, and routinely sample; thus, no USGS U-238 data are available for the RWMC aquifer. The concentrations of U-238 detected are below the $1\text{E-}05$ risk-based concentration for the aquifer. Aquifer detections above background and nondetections for U-238 are illustrated in Figure 4-62.

Year	Quarter	M1S	M3S	M4D	M6S	M7S	M10S	M11S	M12S	M13S	M14S	MISS	M16S	M17S	A11 A31	OW-2
1998	1															
	2	0.78	1.44	0.49	1.12	1.36	0.73									
	3	1.00	1.65	0.61	1.30	1.54	0.93	1.33	1.43	1.38	1.29					
	4															
1999	1															
	2	0.93	1.37	0.42	1.22	1.33	0.66	1.37	1.54	1.36	1.51					
	3	0.87	1.40	0.42	1.21	1.09	0.71	1.26		1.48	1.24					
	4	0.87	1.27	1.49	1.23	1.31	0.79	1.24	1.38	1.21	1.43					
2000	1	0.89		0.40	1.20	1.28	0.57	1.27	1.31	1.32	1.47	1.07	1.38			
	2													1.15		
	3	0.89	1.44	0.42	1.31	1.40	0.63	1.20	1.44	1.28	1.56	1.23	1.31	1.31		
	4	1.14	1.32	0.52	1.05	1.32	0.84	1.16		1.21	1.69	0.84	1.28	1.23	0.90	1.84
2001	1	0.89	1.61		1.12	1.15		1.14	1.64	1.09	1.27	1.14	1.23	1.19	0.92	1.56
	2	0.85	1.37	0.56	1.12	1.32		1.13	1.38	1.25	1.27	1.22	1.19	1.20	1.19	1.46
	3															
	4															
Key			U-233/234 was analyzed for, but not detected.													
		x.xx	U-233/234 was detected at aquifer background levels (1.1 pCi/L).													
			U-233/234 was detected above aquifer background, but below the risk-based concentration (RBC) (6.7 pCi/L).													
			U-233/234 was detected above the RBC.													
		If more than one detection occurred in a well in a single quarter, only the highest concentration is listed.														

Figure 4-60. Occurrence of uranium-233/234 nondetections and detections at or above background in aquifer wells monitored by the Idaho National Engineering and Environmental Laboratory.

Year	Quarter	M1S	M3S	M4D	M6S	M7S	M10S	M11S	M12S	M13S	M14S	M15S	M16S	M17S	A11	OW-2
1998	1															
	2															
	3	0.091		0.044	0.088	0.086		0.079	0.082	0.049						
	4															
1999	1		0.058						0.040	0.044	0.071					
	2	0.050				0.038		0.041	0.044		0.051					
	3		0.039					0.036								
	4		0.040		0.031	0.050			0.034		0.030					
2000	1															
	2													0.035		
	3		0.041		0.037				0.031		0.039		0.040			
	4	0.037	0.051			0.046	0.029	0.029		0.044	0.064	0.020		0.041	0.046	
2001	1															
	2		0.038		0.047	0.040		0.027	0.062	0.035	0.046	0.055	0.113	0.044		0.177
	3															
	4															
Key			U-235/236 was analyzed for, but not detected.													
		x.xx	U-235/236 was detected at aquifer background levels (0.05 pCi/L).													
			U-235/236 was detected above aquifer background, but below the risk-based concentration (RBC) (6.6 pCi/L).													
			U-235/236 was detected above the RBC.													
	If more than one detection occurred in a well in a single quarter, only the highest concentration is listed.															

Figure 4-61. Occurrence of uranium-235/236 nondetections and detections at or above background in aquifer wells monitored by the Idaho National Engineering and Environmental Laboratory.

Year	Quarter	M1S	M3S	M4D	M6S	M7S	M10S	M11S	M12S	M13S	M14S	M15S	M16S	M17S	A11A31	OW-2
1998	1															
	2	0.35	0.60	0.25	0.54	0.56	0.42									
	3	0.53	0.64	0.33	0.65	0.74	0.46	0.66	0.72	0.69	0.58					
	4															
1999	1	0.38	0.73	0.23	0.60	0.51	0.35	0.53	0.75	0.54	0.63					
	2	0.43	0.62	0.32	0.58	0.67	0.27	0.55	0.72	0.54	0.71					
	3	0.34	0.65	0.28	0.53	0.52	0.32	0.52		0.55	0.65					
	4	0.40	0.65	0.67	0.58	0.69	0.35	0.50	0.64	0.48	0.60					
2000	1	0.46	0.68	0.22	0.56	0.58	0.28	0.57	0.61	0.55	0.62	0.57	0.66			
	2													0.63		
	3	0.43	0.72	0.23	0.52	0.68	0.33	0.47	0.68	0.61	0.67	0.55	0.60	0.58		
	4	0.53	0.60	0.25	0.45	0.65	0.37	0.44		0.51	0.71	0.39	0.59	0.60	0.41	0.88
2001	1	0.41	0.77	0.25	0.45	0.45		0.49	0.58	0.54	0.58	0.51	0.63	0.63	0.48	0.85
	2	0.41	0.65	0.30	0.58	0.62		0.42	0.67	0.49	0.60	0.56	0.53	0.51	0.54	0.64
	3															
	4															
Key			U-238 was analyzed for, but not detected.													
		x.xx	U-238 was detected at aquifer background levels (1.1 pCi/L).													
			U-238 was detected above aquifer background (1.1 pCi/L), but below the risk-based concentration (RBC) (5.5 pCi/L).													
			U-238 was detected above the RBC.													
			If more than one detection occurred in a well in a single quarter, only the highest concentration is listed.													

Figure 4-62. Occurrence of uranium-238 nondetections and detections at or above background in aquifer wells monitored by the Idaho National Engineering and Environmental Laboratory.

4.6.19.3.4 Uranium Ratios—In 1999, aquifer samples were collected from Wells M1S, M3S, M7S, M10S, M14S, USGS-87, USGS-117, USGS-119, and USGS-120 and sent for TIMS analysis. The aquifer well water samples were filtered and both the filtrate and filtered material were analyzed for U-234, U-235, U-236, and U-238. Natural uranium has a U-238:U-235 atomic ratio of 137.88 and contains no U-236 (Roback et al. 2001). None of the aquifer well samples indicated the presence of anthropic uranium in the aquifer below the RWMC (Roback et al. 2001). The TIMS analysis of the filters and filtrate did not show the presence of U-236 and showed an average U-238:U-235 ratio of 137.82. Thus, the RWMC aquifer has not been impacted by anthropic uranium from the SDA or from upgradient sources. The INEEL routine monitoring program includes evaluating the U-234:U-238 and U-238:U-235 ratios. The U-234:U-238 atomic mass ratios associated with all the INEEL aquifer wells are typical of INEEL aquifer.

4.6.19.4 Summary of Uranium. Uranium was not detected above background levels in the soil and rock collected from vadose zone cores or in the aquifer. However, there are some potential trends developing in the soil moisture samples. The distribution of detected U-233/234, U-235/236, and U-238 above background in the various media are shown in Figures 4-63, 4-64, and 4-65, respectively. With the exception of the lysimeter and perched water samples, all the concentrations of all uranium isotopes are around background. Table 4-19 shows the detection rates and E-5 risk-based concentration exceedance rates in each of the media for each uranium isotope.

Uranium isotopes are elevated in some lysimeter samples. Routine monitoring results from the shallow lysimeters suggest that there is an emerging trend in anthropic uranium around the Pad A area and at the western end of the SDA. Samples from PA03 and W23 consistently have higher concentrations of all the uranium isotopes, and the low-level TIMS results suggest that uranium from Wells W23 and 98-5 on the west end of the SDA deviate from natural. The U-233/234:U-238 ratio in W23 suggests that there is depleted uranium in that well. Uranium-233/234 and U-238 were increasing in the lysimeter samples from PA03 and W23, and the U-235/236 was elevated. Many of the lysimeter samples exceeded the aquifer risk-based concentration for U-233/234 and U-238.

Uranium concentrations were elevated in intermediate depth lysimeters near Pit 5 and Pad A, and were slightly elevated in Well I-IS, a relatively new well on the west end of the SDA. Uranium ratios on the TIMS data confirm that enriched uranium (i.e., anthropic) is present in TW1. The TIMS results from the other lysimeters were inconclusive.

Uranium isotopes do not appear to be elevated in the deeper vadose zone. The TIMS data suggest the possibility of anthropic uranium in the perched water from Well 8802D at around 220 ft deep, but no conclusion can be drawn from one sample result.

Ratios calculated for the vadose zone core, lysimeter, perched water, and aquifer samples do not provide strong evidence that anthropic uranium is widespread throughout the vadose zone beneath the RWMC. Ratios for the vadose zone cores and the aquifer were indicative of natural uranium. Ratios for the soil moisture and perched water suggest anthropic uranium is present. Depleted uranium trends may be developing in the shallow lysimeter samples at the west end of the SDA, and depleted uranium has been detected in the perched water sampled around 214 ft deep. Ratios for the intermediate vadose zone (35 to 140 ft) indicate the presence of enriched uranium in the Pit 5 area.

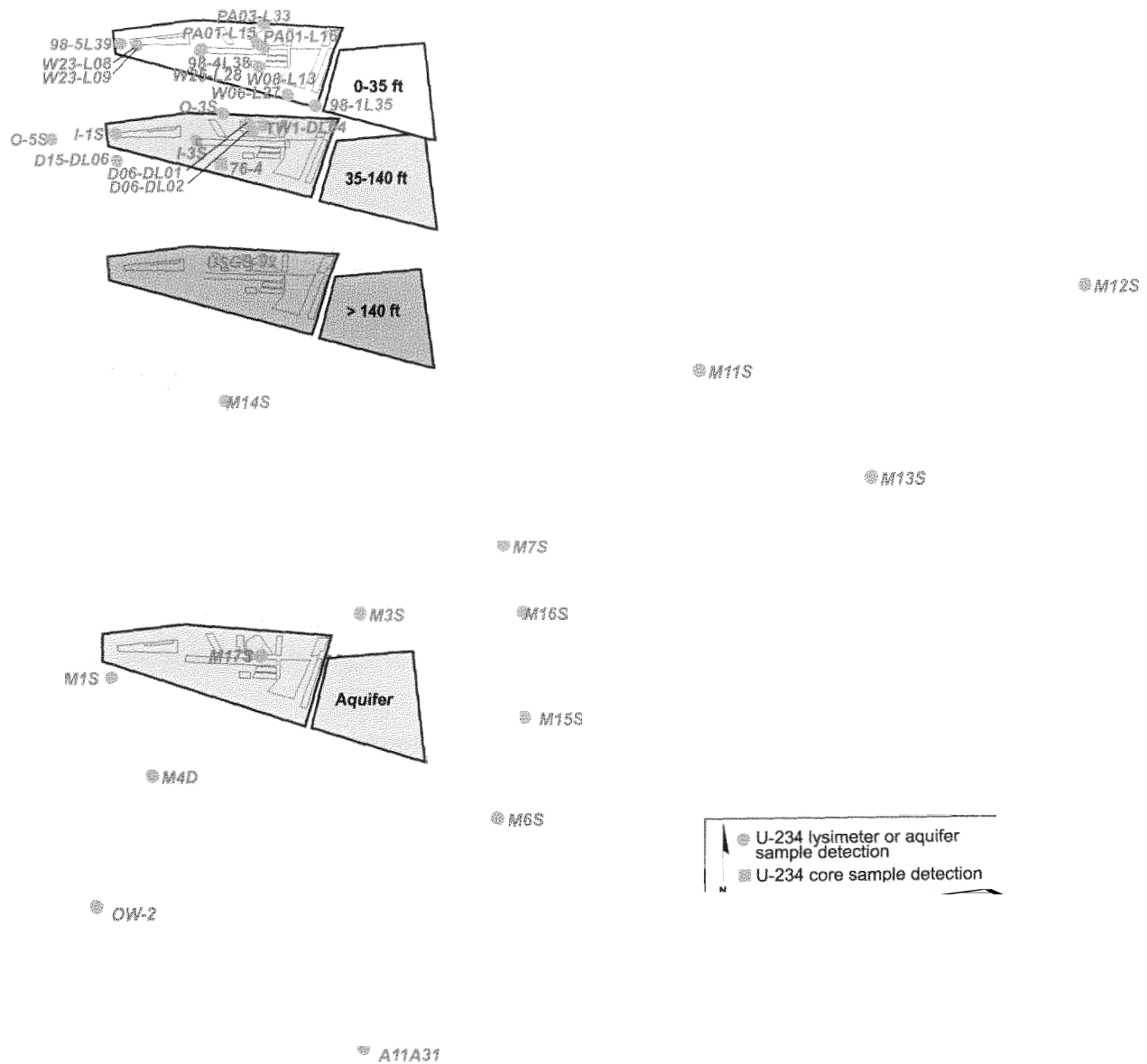


Figure 4-63. The distribution of detected uranium-233/234 above background in the vadose zone core, lysimeter, perched water, and aquifer samples at the Radioactive Waste Management Complex.

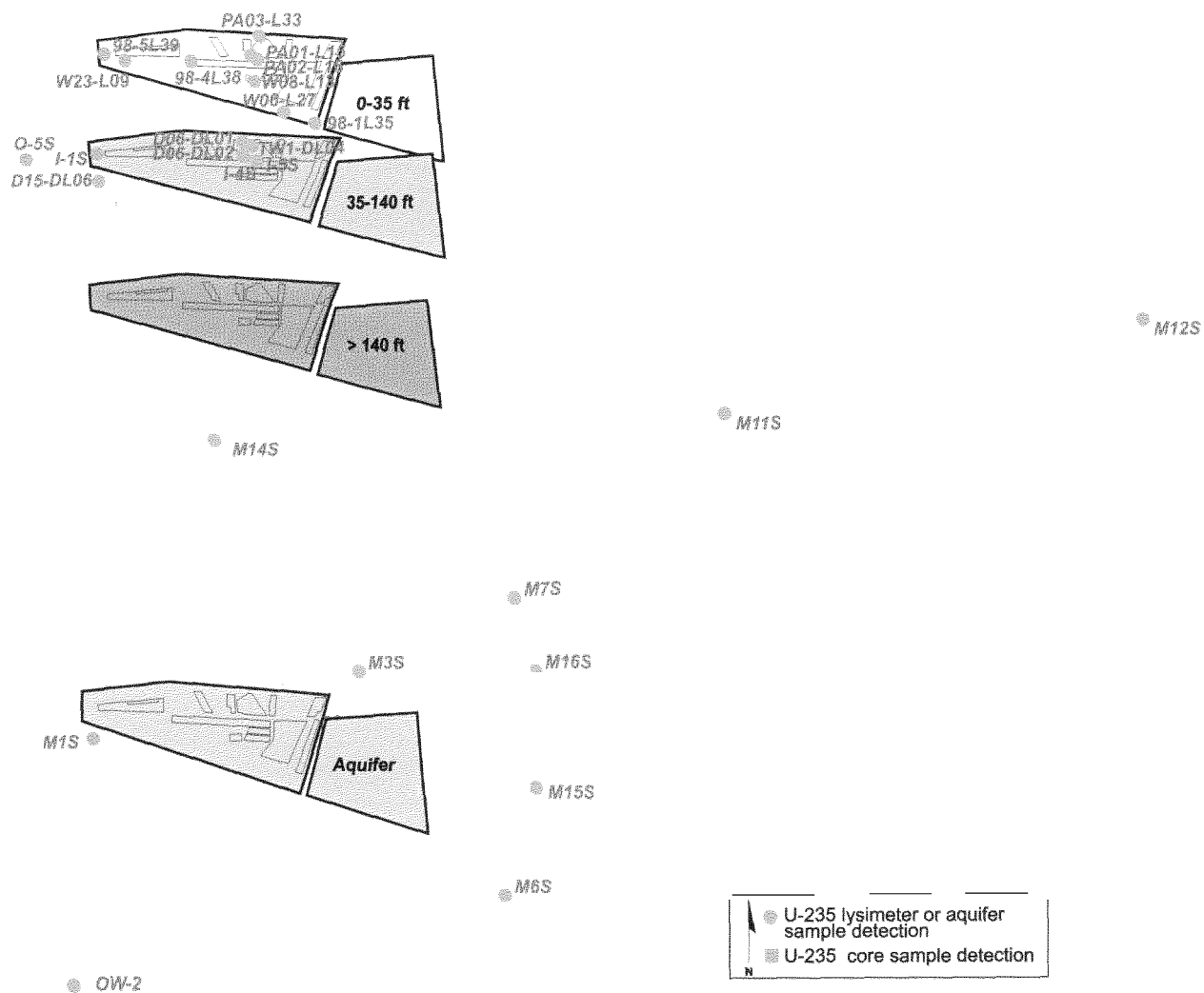


Figure 4-64. The distribution of uranium-235/236 positive detections greater than background levels in vadose zone cores, soil moisture, perched water and aquifer samples at the Radioactive Waste Management Complex.

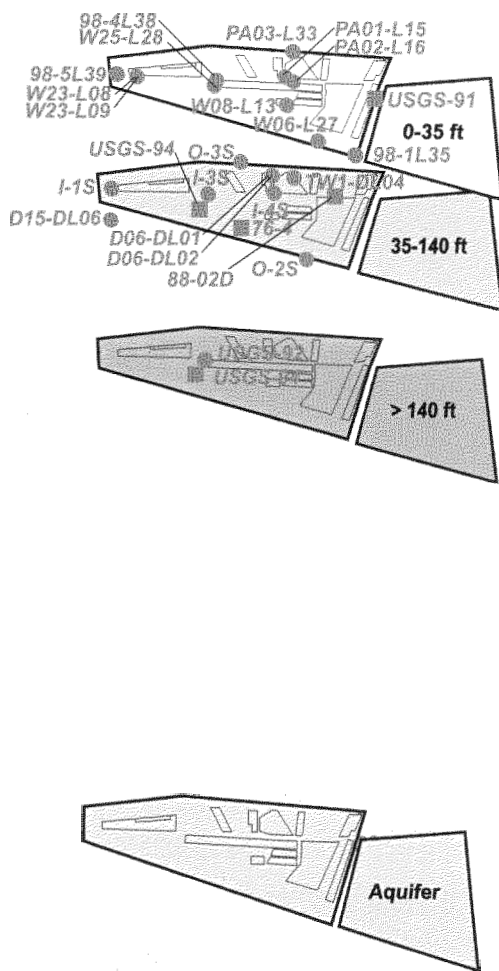


Figure 4-65. The distribution of uranium-238 positive detections greater than background levels in vadose zone cores, soil moisture, perched water, and aquifer samples at the Radioactive Waste Management Complex.

Table 4-1 19. Detection rates and 1E-05 risk-based concentration exceedance rates for uranium isotopes in all media.

Sampled Media	Detection Rate	Range	Risk-Based Concentration Exceedance Rate (%)	Wells >Risk-Based Concentration
U-233/234				
Vadose zone 0 to 35 ft				
Cores	27	0.7 to 0.99 pCi/g	0	None
Soil moisture	98.3	3.69 to 87.0 pCi/L	75	98-1, 98-5, PA01, PA02, PA03, W06, W08, W23
Vadose zone 35 to 140 ft				
Cores	55.0	0.4 to 1.7 pCi/g	0	None
Soil moisture	77.0	1.68 to 111 pCi/L	56	D06, I-1S, I-3S, O-3S, TW1
Vadose zone 140 to 250 ft				
Cores	61.1	0.5 to 1.21 pCi/g	0	None
Soil moisture	42.96	0.5 to 7.47 pCi/L	14.3	USGS-92
Vadose zone more than 250 ft				
Cores	No data	No data	No data	No data
Soil moisture	No data	No data	No data	No data
Aquifer	84.8	0.4 to 1.84 pCi/L	0	None
U235/236				
Vadose zone 0 to 35 ft				
Cores	0	–	0	None
Soil moisture	34.4	0.35 to 4.4 pCi/L	0	None
Vadose zone 35 to 140 ft				
Cores	12.2	0.02 to 0.06 pCi/g	0	None
Soil moisture	52.0	0.59 to 8.2 pCi/L	2.1	TW1
Vadose zone 140 to 250 ft				
Cores	19.4	0.05 to 0.12 pCi/g	0	None
Soil moisture	0	–	0	None
Vadose zone more than 250 ft				
Cores	No data	No data	No data	No data
Soil moisture	No data	No data	No data	No data
Aquifer	38.0	0.020 to 0.177 pCi/L	0	None
U-238				
Vadose zone 0 to 35 ft				
Cores	61.5	0.6 to 5.4 pCi/g	0	None
Soil moisture	99.2	0.26 to 53 pCi/L	73.8	98-1, 98-5, PA01, PA02, PA03, W08, W23
Vadose zone 35 to 140 ft				
Cores	61.4	0.3 to 5.9 pCi/g	0	None
Soil moisture	79.2	0.68 to 52.6 pCi/L	52.1	D06, I-1S, TW1
Vadose zone 140 to 250 ft				
Cores	69.2	0.56 to 7.5 pCi/g	0	None
Soil moisture	33.3	0.37 to 4.7 pCi/L	0	None
Vadose zone more than 250 ft				
Cores	No data	No data	No data	No data
Soil moisture	No data	No data	No data	No data
Aquifer	93.0	0.21 to 0.88 pCi/L	0	None

4.7 Inorganic Contaminants

4.7.1 Nitrates

Nitrate (NO_3^-) is an inorganic anion generally associated with nitrate-containing salts or fertilizers, or the aerobic decomposition of organic matter. Because it is an anion, it is readily transported through the vadose zone with migrating water. Nitrates exist in the SRPA at detectable concentrations of about 1 to 2 mg/L at background locations (Knobel, Orr, and Cecil 1992). Excess nitrate in groundwater is most commonly associated with large-scale farming operations or feedlots, from the addition of nitrogen-containing fertilizers, or from excessive manure in stockpiles or lagoons. Most of the nitrates in the SDA originate from nitrate salts used in weapons manufacturing. Nitrate was identified in the IRA as a COPC, primarily for the groundwater ingestion exposure pathway (Becker et al. 1998).

The nitrate sample data are presented in the following tables as they were reported in the limitations and validation or laboratory reports (see Section 4.5.3). Most of the data were reported as “nitrate” or “nitrate-N.” The “nitrate-N” probably indicates that the concentration obtained by the analysis was reported on a nitrogen basis rather than as nitrate. Results in this section are compared to the MCL of 10 mg/L nitrates.

4.7.1.1 Waste Zone. About $4.35\text{E}+08$ g of nitrates were disposed of in the SDA. Table 4-120 identifies the waste streams containing the nitrate inventory mass.

Table 4-120. Waste streams containing nitrates.

Waste Stream Code	Waste Stream Description	Mass (g)	Proportion of Total Mass
PDA-RFO- 1A	Nitrate salts RFO sludge	2.31E+08	53
RFO-DOW- 17H	Nitrate salts in sludge	1.57E+08	36
CPP-601-4H	Acidic aqueous liquid	4.79E+07	11
Total Disposals		4.35E+08	100

4.7.1.2 Surface. Nitrates have not been measured in routine surface sampling.

4.7.7.3 Vadose Zone. The distributions of nitrate in vadose zone core, soil moisture, and perched water in the various depth intervals are discussed below.

4.7.1.3.1 Core Samples —A total of 27 nitrate and nitrite analyses were performed on core samples from the 1993 investigation, all of which were positive detections (see Table 4-121).

4.7.7.4 Lysimeter Samples at Depths of 0 to 35 ft. A total of 72 nitrate and nitrite analyses were performed on soil moisture samples collected from 10 shallow vadose zone lysimeters between 1994 and May 2001. Of these, there were 54 detections, 37 of which exceed the MCL of 10 mg/L used for comparison (see Table 4-122).

Table 4- 121. Detections of nitrates in Radioactive Waste Management Complex core samples.

Borehole Identification	Sample Depth (ft)	Name in Report ^a	Concentration (mg/kg)	Date
76-1	204.9 to 205.9	Nitrate + Nitrite-N	1.39	May 1993
76-2	78 to 79	Nitrate + Nitrite-N	1.72	May 1993
76-3	94 to 95	Nitrate-N	0.23	May 1993
	215 to 215.8	Nitrate-N	0.22	May 1993
76-5	45.1 to 46.0	Nitrate-N	0.29	May 1993
	48.0 to 49.0	Nitrate-N	0.53	May 1993
77-2	72.6 to 73.5	Nitrate-N	0.47	May 1993
	199.5 to 200.3	Nitrate-N	0.57	May 1993
78-2	126.5 to 127.8	Nitrate-N	0.24	May 1993
	226.3 to 230.1	Nitrate-N	0.38	May 1993
78-5	130.6 to 132.0	Nitrate-N	0.34	May 1993
	172.9 to 173.7	Nitrate-N	0.25	May 1993
79-2	27.0 to 29.0	Nitrate-N	0.38	May 1993
	70.0 to 70.6	Nitrate-N	0.37	May 1993
	221.5 to 222.5	Nitrate-N	0.33	May 1993
79-3	53.9 to 55.0	Nitrate-N	0.23	May 1993
	100.6 to 101.8	Nitrate-N	0.26	May 1993
8801D	43.2 to 44.7	Nitrate-N	0.91	May 1993
	87.0 to 89.0	Nitrate-N	0.91	May 1993
	170.3 to 171.3	Nitrate-N	2.94	May 1993
USGS-91	23.4 to 25.0	Nitrate-N	2.00	May 1993
	106.0 to 108.0	Nitrate-N	1.86	May 1993
USGS-93	14.0 to 16.0	Nitrate-N	0.57	May 1993
	222.5 to 236.0	Nitrate-N	0.75	May 1993
USGS-94	26.1 to 28.0	Nitrate-N	0.21	May 1993
USGS-95	76.0 to 114.4	Nitrate-N	0.29	May 1993
	235.2 to 239.0	Nitrate-N	0.25	May 1993

a. Compound name is presented as reported in Loehr, Einerson, and Jorgensen (1993). It is unknown whether the data represent nitrate or nitrogen concentrations in the samples.

Table 4-122. Detections of nitrates and nitrites from shallow lysimeters at depths of 0 to 35 ft.

Lysimeter	Depth (ft)	Name in Database'	Concentration (mg/L)	Date
W23-LO8	11.8	Nitratflitrite-N	30.8	April 1997
		Nitrate/Nitrite-N	277	August 1997
		Nitrate	102	August 1998
		Nitrate	0.12	March 2000
W23-L09	7.7	Nitrate/Nitrite-N	18.3	April 1997
		Nitrate/Nitrite-N		August 1997
		Nitrate/Nitrite-N		August 1997
		Nitrate	48.8	August 1998
		Nitrate-N	0.42	June 2000
W08-L13	11.3	Nitratflitrite-N	34.1	April 1997
		Nitrate/Nitrite-N		August 1997
		Nitrate/Nitrite-N		August 1997
		Nitrate+Nitrite-N	30.7	June 2000
W08-L14	6.2	Nitrate/Nitrite-N	44.3	April 1997
		Nitrate/Nitrite-N		August 1997
		Nitrate/Nitrite-N		August 1997
PA01-L15	14.3	Nitratflitrite-N	6.79	June 1994
		Nitrate/Nitrite-N	6.82	May 1995
		Nitrate	16.9	April 1996
		Nitrate/Nitrite-N	5.65	April 1997
		Nitrate/Nitrite-N	6.38	August 1997
		Nitrate	26.3	August 1998
		Nitrate	29.9	December 1998
PA02-L16	8.7	Nitrate/Nitrite-N	47.5	June 1994
		Nitrate-N	42.8	April 1995
		Nitrate	242	April 1996
		Nitrate/Nitrite-N	48.5	April 1997
		Nitrate	47.3	August 1997
		Nitratflitrite-N	44.8	August 1997
		Nitrate/Nitrite-N	55.6	February 1998
		Nitrate	45.9	April 1998
		Nitrate	205	August 1998
		Nitrate	232	December 1998
		Nitrate	47.0	March 2000
W06-L27	11.8	Nitrate-N	30.3	May 2001
		Nitrate/Nitrite-N	3.67	April 1997
		Nitrate/Nitrite-N	2.90	August 1997
		Nitrate/Nitrite-N		August 1997
		Nitrate/Nitrite-N		February 1998
		Nitrate	9.30	August 1998
		Nitrate	112	December 1998
		Nitrate-N	7.89	May 2001

Table 4-122. (continued).

Lysimeter	Depth (ft)	Name in Database ^a	Concentration (mg/L)	Date
W25-L28	15.5	Nitrate/Nitrite-N	21.3	April 1997
		Nitrate/Nitrite-N	10.2	August 1997
		Nitrate/Nitrite-N	21.2	August 1997
		Nitrate+Nitrite-N	26.2	November 1999
		Nitrate-N	26.7	June 2000
PA03-L33	10	Nitrate	8.93	August 1997
		Nitrate/Nitrite-N	10.6	February 1998
		Nitrate	9.97	April 1998
		Nitrate	8.0	March 2000
98-5L39 (SDA10)	10.5	Nitrate	4.63	April 1998
		Nitrate	27.0	August 1998
		Nitrate	16.8	December 1998

a Compound name is presented as reported by the laboratory. It is unknown whether the data represent nitrate or nitrogen concentrations in the sample.

Values in **red bold** exceed the maximum contaminant level of 10 mg/L. Highlighted data are the original and confirmation results.

4.7.1.4.1 Lysimeter Samples at Depths of 35 to 140 ft—A total of 29 nitrate and nitrite analyses were performed by the INEEL on soil moisture samples collected from seven lysimeters between 1995 and May 2001. Of these there were 18 detections, 12 of which exceed the MCL of 10 mg/L used for comparison (see Table 4-123);

Table 4-123. Detected nitrates in lysimeter samples at depths of 35 to 140 ft.

Lysimeter	Depth (ft)	Name in Database ^a	Concentration (mg/L)	Date
D06-DL01	88	Nitrate	17.2	August 1997
		Nitrate	9.03	April 1998
D06-DL02	44	Nitrate + Nitrite-N	32.3	April 1995
		Nitrate	24.0	August 1997
		Nitrate	23.7	April 1998
		Nitrate	14.0	March 2000
TW1-DL04	101.7	Nitrate + Nitrite-N	2.02	April 1995
		Nitrate + Nitrite-N	2.73	April 1995
		Nitrate	41.9	April 1996
		Nitrate	42.0	April 1996
		Nitrate/Nitrite-N	13.1	February 1998
		Nitrate	14.2	April 1998
		Nitrate	13.0	March 2000
		Nitrate-N	7.8	May 2001
D15-DL06	98	Nitrate/Nitrite-N	13.3	April 1997
		Nitrate/Nitrite-N	0.76	August 1997
I-2S DL11	92	Nitrate + Nitrite-N	4.9	May 2001
I-3S DL13	93	Nitrate + Nitrite-N	1.41	May 2001

a. Results are presented as reported by the laboratory. It is unknown whether the data represent nitrate or nitrogen concentrations in the sample.

Note: Values in **red bold** exceed the maximum contaminant level of 10 mg/L. Highlighted data are the original and confirmation results.

4.7.1.4.2 Perched Water Samples at Depths Greater than 140ft—A total of five nitrate and nitrite analyses were performed by the INEEL on perched water samples collected from two wells between 1997 and May 2001. All samples contained detectable concentrations of nitrates, but none of the concentrations exceeded the MCL of 10 mg/L used for comparison (see Table 4-124).

Table 4-124. Detections of nitrates in the vadose zone soil moisture at depths greater than 140 ft.

Perched Water Well	Depth (ft)	Name in Database	Concentration (mg/L)	Date
USGS-92	214	Nitrate/Nitrite-N	4.07	April 1997
		Nitrate/Nitrite-N	0.58	August 1997
		Nitrate/Nitrite-N	1.96	February 1998
		NO ₂ +NO ₃ -N	1.05	October 1999
8802D	220	Nitrate/Nitrite-N	3.81	February 1998

a. Results are presented as reported by the laboratory. It is unknown whether the data represent nitrate or nitrogen concentrations in the sample.

4.7.1.5 Aquifer. Low levels of nitrates have been detected in the aquifer-monitoring wells in the vicinity of the RWMC. All 16 of the RWMC INEEL wells sampled from 1992 to May 2001 had nitrate concentrations below the MCLs and were typical of levels normally detected in the aquifer. The reported levels of nitrates typically found in the SRPA are 1 to 2 mg/L, with concentrations that range from 0.4 to 5 mg/L (Knobel, Orr, and Cecil 1992). The range of concentrations associated with the RWMC aquifer monitoring wells from 1992 to April 2001 (273 measurements) varied from a minimum of 0.28 mg/L to a maximum of 2.9 g/L, with the majority of values between 0.5 and 1.3 mg/L. Well M6S shows an increasing nitrate trend (see Figure 4-66).

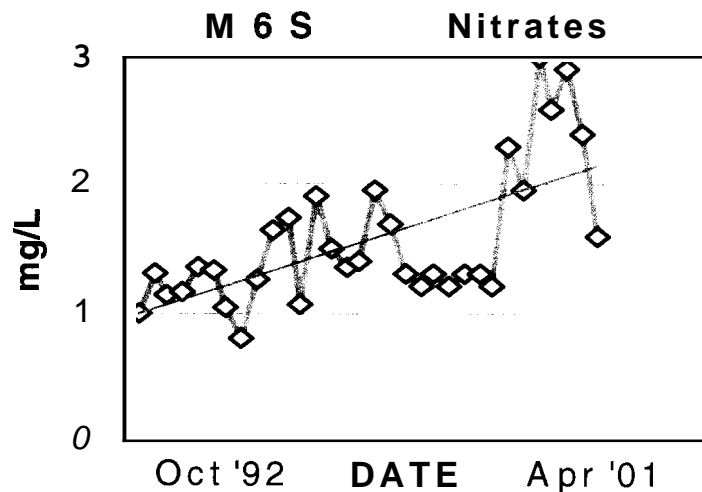


Figure 4-66. Nitrate concentrations in Well M6S from 1992 to 2001.

The trend observed in Well M6S began shortly after the well was installed in 1992. The cause of the trend is unknown. Well M6S was cleaned out in February 2001 as part of routine well maintenance

and various types of corrosion products and other debris were removed from the bottom of the well." Nitrate concentrations since the well cleaning have declined; however, it will require several more sampling events before a decreasing trend can be substantiated.

Besides the wells routinely sampled by the INEEL, the USGS manages and regularly samples eight other wells in the vicinity of the RWMC. Most of these wells have been monitored by the USGS for nitrates since 1981; however, the RWMC Production Well was first monitored for nitrates in 1974. All of the RWMC USGS wells sampled from 1974 to April 2001 had nitrate concentrations around background (i.e., 1 to 2 mg/L). None of the USGS results exceeded the MCL (10 mg/L). The range of concentrations associated with the USGS aquifer monitoring wells from 1974 to April 2001 (139 measurements) varied from a minimum of 0 mg/L to a maximum of 2.1 mg/L, with the majority of values between 0.6 and 1.4 mg/L.

The concentrations of nitrates detected in the RWMC aquifer monitoring wells are below 58.4 mg/L, which is the concentration associated with the hazard index of one. There are no risk-based concentrations associated with nitrates because nitrates are not carcinogenic.

4.8 Volatile Organic Compounds

Carbon tetrachloride, PCE, and methylene chloride have been identified as COPCs, primarily for the groundwater ingestion exposure pathway. Information about the disposal inventories and the detections of these compounds in environmental media is presented in the following subsections.

4.8.1 Carbon Tetrachloride

Carbon tetrachloride is a chlorinated aliphatic hydrocarbon that can exist in multiple phases including: (a) a non-aqueous phase liquid, (b) a vapor phase in the soil gas, (c) an aqueous phase dissolved in soil water, and (d) a solid phase sorbed onto soil particles. In the vadose zone, CCl₄ will partition into all the phases, seeking an equilibrium condition. At the SDA, however, a liquid phase is unlikely because of the high viscosity of the treated 743-series waste.

Many investigations have been conducted to determine the extent of CCl₄ contamination and other VOCs at the SDA. These investigations have detected CCl₄ in surficial sediments, vadose zone soil gas, vadose zone soil water (perched water and lysimeters), and the aquifer beneath and surrounding the **SDA**. Carbon tetrachloride vapor has also been detected emanating from the soil surface by surface isolation flux chambers. Sources of CCl₄ information and data include, but are not limited to, Mann and Knobel (1987), Mann (1990), Liszewski and Mann (1993), Duncan, Troutman, and Sondrup (1993), Sondrup and Martian (1995), Greene and Tucker (1998), Rodriguez (2000), Miller and Varvel (2001), Housley (2002), the **USGS** Aquifer Quality Database, and results from routine monitoring.

Careful attention should be paid to the different concentration units for CCl₄ in the gaseous-phase and aqueous-phase. Aqueous-phase concentrations are often given in µg/L (mass of contaminant/volume of aqueous solution). For low concentrations, this is the same as parts per billion, which is a mass/mass ratio (e.g., µg of contaminant per kg of solution). Gaseous-phase concentrations on the other hand are given as parts per million by volume (ppmv), or parts per billion by volume (ppbv), both of which are a volume-to-volume ratio.

a. Dooley, Kirk. personal conversation, September 25, 2001, Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho.

4.8.1.1 Waste Zone

4.8.1.1.1 Inventory and Distribution—The primary source of CCl_4 at the SDA is 743-series waste drums shipped from DOE's Rocky Flats Plant between 1966 and 1970 (Miller and Varvel 2001). Initially 9,691 743-series waste drums were buried in multiple pits in the **SDA**, including Pits 4, 5, 6, 9, 10, 11, and 12. Of these, 1,015 drums were subsequently retrieved from Pits 11 and 12 in the 1970s, leaving 8,676 drums of 743-series waste drums in the **SDA**. The estimated mass of CCl_4 contained in these 8,676 drums is $8.2\text{E}+05$ kg (Table 4-125) with a standard deviation of $1.4\text{E}+05$ kg (Miller and Varvel 2001). Figure 4-67 displays a drum density burial map for 743-series waste drums. Based on information reported in Miller and Varvel (2001), 6,225 (about 72%) of the 8,676 743-series drums buried in the SDA were buried in Pits 4 and 6. Table 4-126 displays the distribution of 743-series drums within the **SDA**.

Table 4-125. Waste streams containing carbon tetrachloride.

Waste Stream Code	Waste Stream Description	Mass (kg)	Proportion of Total Mass (%)
RFO-DOW-15H	Organic sludge	$7.94\text{E}+05$	96.8
RFO-DOW-4H	Paper, rags, and plastic	$2.05\text{E}+04$	2.5
Miscellaneous	Miscellaneous minor streams	$5.74\text{E}+03$	0.7
Total Disposals		$8.20\text{E}+05$	100

Table 4-126. Post-retrieval distribution of 743-series waste drums.

Pit	Number of Drums (% of total)
Pit 4	3,701 (42.6%)
Pit 5	49 (0.6%)
Pit 6	2,524 (29.1%)
Pit 9	1,144 (13.2%)
Pit 10	1,258 (14.5%)
Total	8,676 (100%)

Though a considerable amount of VOCs have been released from the 743-series waste into the vadose zone, a significant portion may still yet reside in sludge in the pits. Estimating the mass of VOCs remaining in source pits and trenches in the **SDA** is important in supporting decisions relating to **SDA** remediation.

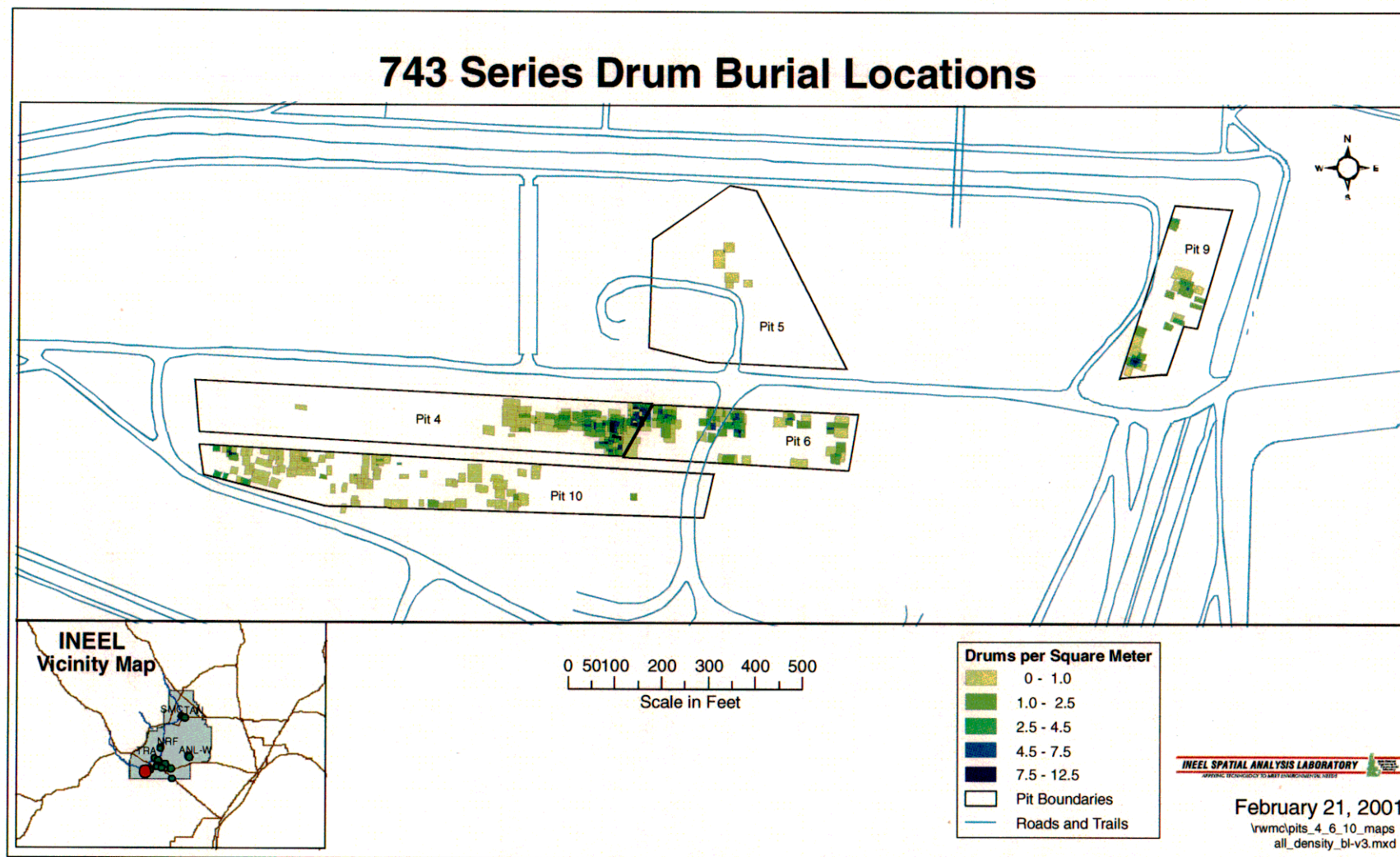


Figure 4-67. Map of the Subsurface Disposal Area showing relative drum burial densities for 743-series waste drums.

A study was recently conducted that provides a preliminary estimate of the mass of CCl₄ and total VOCs remaining in the SDA pits.”The estimate is based on calculations of CCl₄ and total VOC mass originally buried in the SDA (Miller and Varvel 2001) and the results of recent chlorine logging in the waste. The chlorine logging was performed in probeholes along the 743-series transect in Pit 4 and provides the basis for estimating the current mass of CCl₄ and total VOCs at select locations within the SDA. The study attempted to quantify and propagate random errors in both data sets to provide an estimate of the uncertainty in the final VOC mass estimate.

The results of the study estimate that 51% (±20%) of the initial chlorine mass buried in the SDA still remains. If it is assumed that the VOCs have not undergone chemical transformation since burial, and that the relative mass fractions of each VOC in 743-series waste has remained constant, the mass of CCl₄ remaining in the pits is estimated to be 4.1E+05 kg with a standard error of 1.5E+05 kg. The mass of total VOCs remaining is estimated to be 5.5E+05 kg with a standard error of 2.0E+05 kg. The study points out that additional work is needed to determine the adequacy of the assumptions and the presence of any bias errors in the supporting analysis, both of which influence the accuracy of the remaining mass estimates.

4.8.1.1.2 Waste Zone Soil Gas Data from Type B Probes — In 2001, 16 Type B vapor probes were installed within the waste zone in the 743 and DU Focus Areas. Eight of the 16 probes are functional and the other eight probes will not currently yield a sample. The probes that will not yield a sample may be clogged, possibly by the sludge from some of the buried waste. Of the 16 probes, nine have been installed in the organic sludge focus area and only three of the nine will yield a sample. The remaining seven waste zone vapor probes have been installed in the depleted uranium focus area where there is less 743-series waste, and five of the seven have yielded a sample.

Two of the functioning vapor ports (DU-08-VP2 and DU-10-VP3) have had vapor samples analyzed by an offsite laboratory and have yielded what is believed to be acceptable results; however, the data have not yet been validated. Table 4-127 lists the names, depths, and preliminary CCl₄ gas concentrations for samples collected from these locations. The 13,000-ppmv concentration measured in DU-08-VP2 is the highest vapor concentration measured at the SDA. This should not be surprising since it is the first sample ever collected from the waste zone. Samples from the remaining functioning vapor ports have been analyzed with a field instrument that has not been reliable. Problems with this instrument are being corrected and additional data will be collected during the next round of vapor port sampling.

Table 4-127. Unvalidated carbon tetrachloride vapor concentrations from Type B vapor probes.

Vapor Port	Port Depth (ft)	CCl ₄ Concentration (ppmv)	Date
743-03-VP1	18.0	No sample can be obtained	Not applicable
743-03-VP2	13.3	No sample can be obtained	Not applicable
743-03-VP3	4.8	No sample can be obtained	Not applicable
743-08-VP1	20.2	Not sampled	Not applicable
743-08-VP2	13.4	Not sampled	Not applicable
743-08-VP3	4.9	No sample can be obtained	Not applicable
743-18-VPI	20.0	No sample can be obtained	Not applicable

a. Miller, Eric C., A. Jeffrey Sondrup, and Nicholas E. Josten, 2002, “Preliminary Estimate of Carbon Tetrachloride and Total Volatile Organic Compound Mass Remaining in SDA Pits (Draft),” **INTEWEXT-02-00140** Rev. A, draft, Idaho National Engineering and Environmental Laboratory, Bechtel BWXT Idaho, LLC, Idaho Falls, Idaho.

Table 4-127. (continued).

Vapor Port	Port Depth (ft)	CCl ₄ Concentration (ppmv)	Date
743-18-VP3	7.6	No sample can be obtained	Not applicable
743-18-VP4	14.6	Not sampled	Not applicable
DU-08-VP2	15.8	13,000	November 2001
DU-10-VP1	11.6	No sample can be obtained	Not applicable
DU-10-VP2	10.0	Not sampled	Not applicable
DU-10-VP3	6.2	610	November 2001
DU-14-VP1	16.1	No sample can be obtained	Not applicable
DU-14-VP2	11.7	Not sampled	Not applicable
DU-14-VP3	4.9	Not sampled	Not applicable

4.8.7.2 Surface. Gaseous emissions from the soil surface of the SDA were collected in December 1992 and July 1993 using a surface isolation flux chamber. Measurements were made in the 12 locations indicated in Figure 4-68. The results for CCl₄, in terms of concentration within the sample canisters and emission rates, are shown in Table 4-128. Emissions of CCl₄ were detected in 10 of the 12 locations. The maximum emission rate for CCl₄ was 56 µg/m²/min at location FC-5 between Pits 4 and 10. The complete results of these studies can be found in Duncan, Troutman, and Sondrup (1993) and Schmidt (1993).

Table 4-128. Summary of carbon tetrachloride data collected from 1992 and 1993 surface flux chamber measurements.

Sample Location	December 1992		July 1993	
	Concentration in Canister (ppbv)	Emission Rate (µg/m ² /minute)	Concentration in Canister	Emission Rate
FC-1	3.3 (3.9) ^a	0.87	4.5 (5.0) ^a	Not detected
FC-2	8.3	2.0	Not detected	Not detected
FC-3	<1	Not detected	Not detected	Not detected
FC-4	8.7	2.1	Not detected	Not detected
FC-5	85	20	240 ^b	56
FC-6	21	5.0	46	10
FC-7	11	2.6	Not detected	Not detected
FC-8	3.2	0.77	Not detected	Not detected
FC-9	2.9	0.70	14	2.1
FC-10	160	38	2.4	Not detected
FC-11	23	5.5	200	46
FC-12	<1	Not detected	Not detected	Not detected

a. Replicate analysis.

b. Reported value is an average of multiple results.

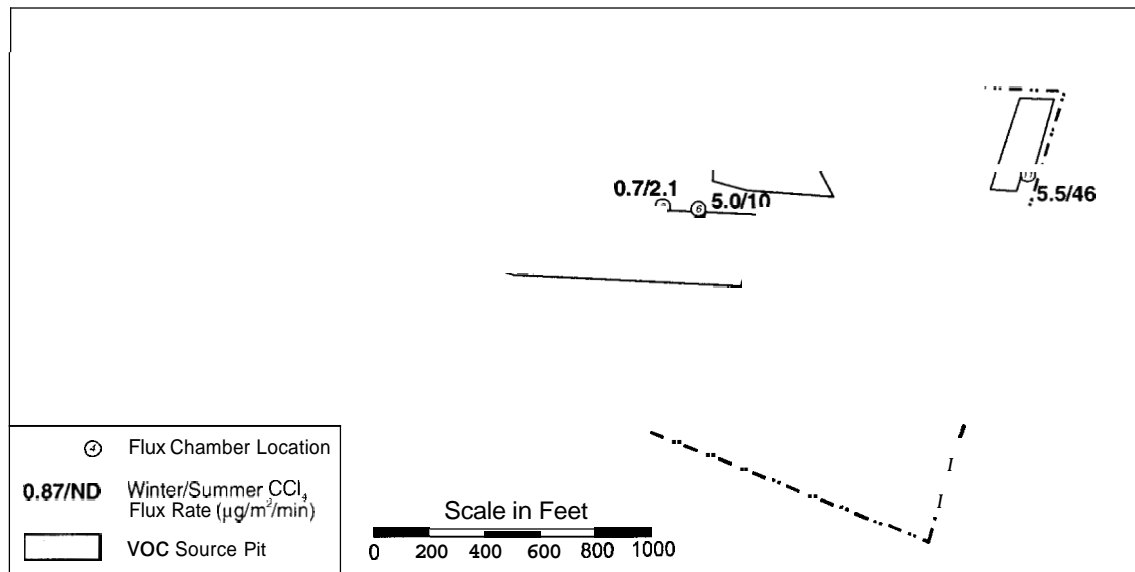


Figure 4-68. Surface flux chamber measurement locations.

4.8.7.3 Vadose Zone. Carbon tetrachloride is ubiquitous in the vadose zone in the vicinity of the **SDA**, as shown by hundreds of gas and water sample analyses. This section discusses the vadose zone sample results, including (a) shallow soil gas survey data, (b) shallow well soil gas data, (c) deep soil gas data, (d) perched water data, and (e) lysimeter data.

4.8.1.3.1 Shallow Soil Gas Survey Data—Four shallow soil gas surveys have been performed at the **SDA**. The first two surveys were conducted in 1987 and 1992 and covered large areas using a relatively course grid spacing. These surveys analyzed samples using portable gas chromatographs and produced respective CCl₄ concentration ranges of 0 to 427 ppmv and 0 to 255 ppmv. The most recent surveys, conducted in 1999 and 2000, used a finer spacing and were focused in areas over Pits 4, 5, 6, and 10, identified by the previous surveys as 743-waste burial locations. These surveys analyzed samples using a Briel and Kjaer portable photoacoustic gas analyzer. The CCl₄ concentration ranges for the 1999 and 2000 surveys are 2 to 7,260 ppmv and 0 to 6,330 ppmv, respectively. Because the 1999 and 2000 surveys were focused over specific pits where 743-series drums are buried, it is not surprising that the maximum measured concentrations are much greater than the first two surveys.

The results of the four surveys generally agree with one another in terms of identifying burial locations of VOCs contained in 743-series waste. Figure 4-69 shows an isopleth of CCl₄ concentrations from the 2000 shallow soil gas survey. To a large degree, this information validates the 743-series waste burial locations shown in Figure 4-67. A summary of all four shallow soil gas surveys can be found in Housley, Sondrup, and Varvel (2001).

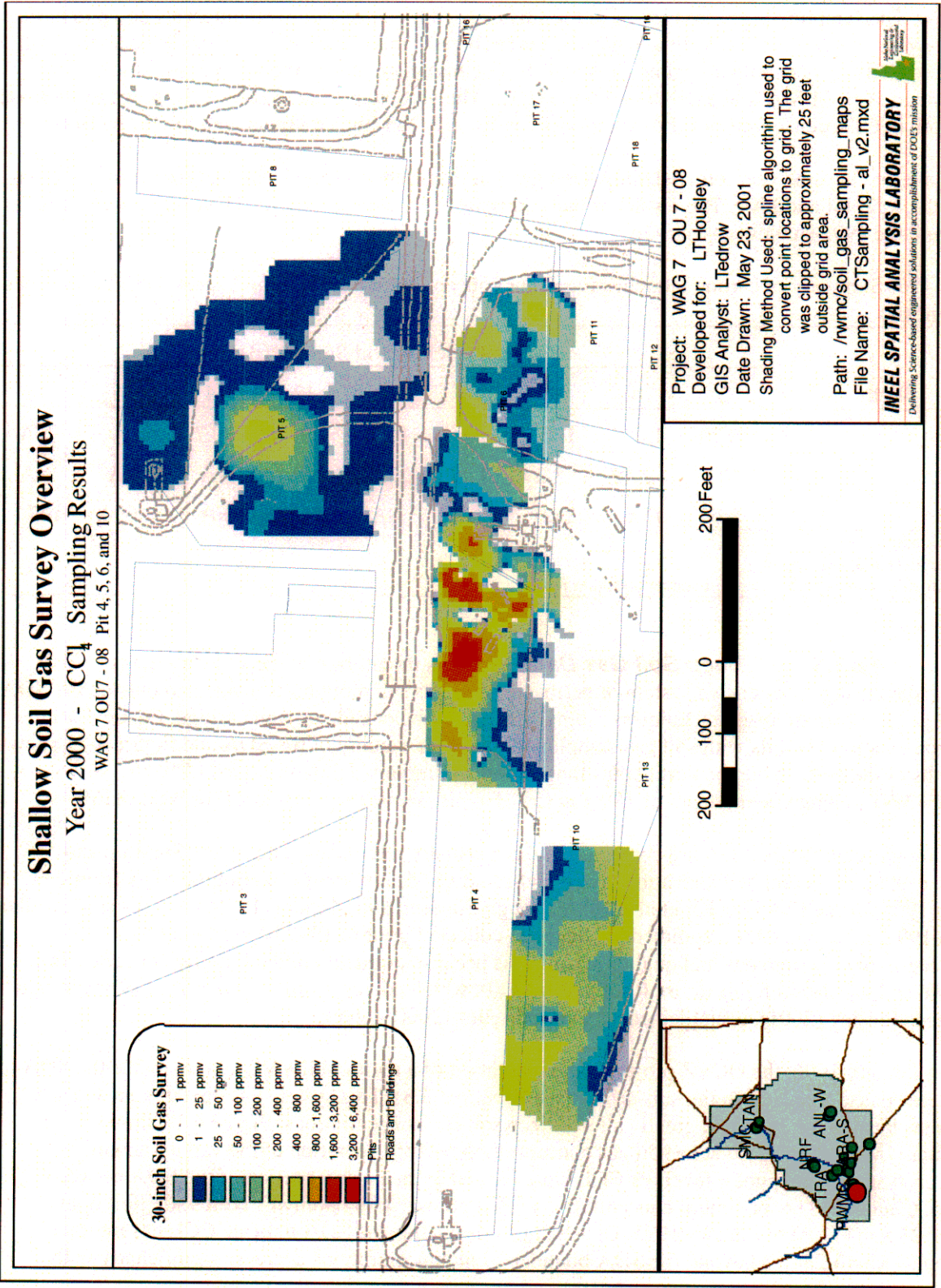


Figure 4-69. Carbon tetrachloride concentrations (ppmv) in shallow soil gas measured during the 2000 shallow soil gas survey.

4.8.1.3.2 Shallow Well Soil Gas Sampling—In August 1992, gas samples were collected from gas sampling ports in Wells TEM1A, TEM2A, and TEM3A (see Figure 4-70 for well locations). The sampling ports are located in the surficial sediments at 2-ft depth intervals down to basalt. Samples were analyzed on-site with a Sentex Scentograph portable gas chromatograph. Results for CCl₄ from these analyses are summarized in Table 4-129. The maximum concentration measured was 103 ppmv in Well TEM-1A at a depth of 4.9 m (16 ft). The vertical profile in each well shows an increase with depth in CCl₄ concentrations. For additional details, see Duncan, Troutman, and Sondrup (1993).

Later in the same year, other shallow well gas samples were collected and analyzed from locations around the Acid Pit and Pit 9. The results of these samples were consistent with TEM-series well sample results and the 1992 shallow gas survey.

Table 4-129. Summary of carbon tetrachloride vapor concentration results from August 1992 TEM-series well samples.

Well	Depth Below Soil Surface (ft)								
	2	4	6	8	10	12	14	16	18
TEM1A	8.79	13.9	13.7	13.6	16.7	20.0	89.7	103	NA
TEM2A	ND	2.49	3.39	17.1	23.8	NA	NA	NA	NA
TEM3A	8.62	13.6	24.0	NA	NA	NA	NA	69.8	147

NA = not applicable
ND = not detected at 0.1 ppm
Note: All values are reported as mean concentration in ppmv.

4.8.1.3.3 Deep Soil Gas Data—Soil gas monitoring in the vadose zone is accomplished using an extensive system of permanent soil gas sampling ports inside and outside the SDA boundary. The ports are made of stainless tubing attached to the outside of well casings. Figure 4-70 shows the location of wells with soil gas-sampling ports in the vicinity of the SDA and Figure 4-71 shows the depths of the ports. Note the port depths range from a minimum depth of 4.6 m (15 ft) in Well WWW-1 to a maximum depth of 180.1 m (591 ft), just above the water table, in Well M13S.

Soil gas data for the SDA are contained in three primary references. The first is Sondrup and Martian (1995) who compiled and summarized VOC soil gas data in the vicinity of the SDA from 1991 through 1995 for the IRA (Becker et al. 1998). Though Sondrup and Martian (1995) contains soil gas data prior to 1992, Izbicki (1992) recommended that data collected prior to 1992 be used only for identification of contaminants and qualitative analysis because of quality and reliability concerns. The other two soil gas data references are Rodriguez (2000), which contains soil gas data from 1992 through 1999; and Housley (2001), a supplement to the Rodriguez (2000) report.

In January 1996, the OCVZ project began operation of a multi-well VVE system inside the SDA to remove gas phase VOCs from the subsurface (see Section 3.2.8). This system has operated on a nearly continuous basis since 1996 and greatly altered deep soil gas concentrations. Figure 4-72 shows conceptually what the vadose zone soil gas concentrations before operation of the vapor-vacuum extraction system. The highest levels of CCl₄ were located in the central portion of the SDA between Pits 4, 5, 6, and 10. The maximum concentration measured was 4,864 ppmv in Well 9302 Port 6, at a depth of 23.5 m (77 ft) in January 1995. Data from wells outside the SDA indicate CCl₄ has migrated more than 1 km (3,281 ft) beyond the SDA boundary, but concentrations decrease significantly with

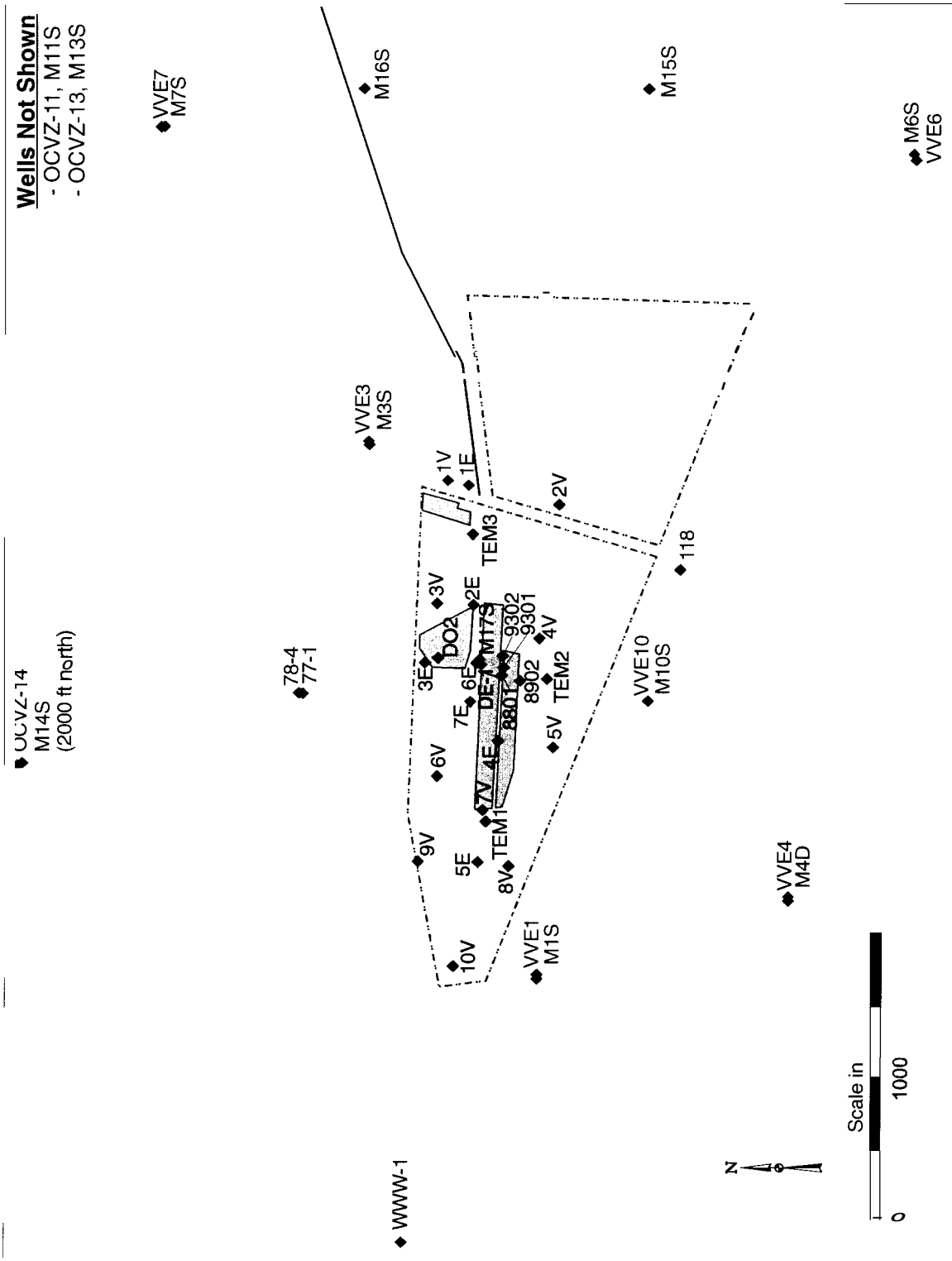


Figure 4-70. Locations of wells in the vicinity of the Subsurface Disposal Area with permanent vapor sampling ports.

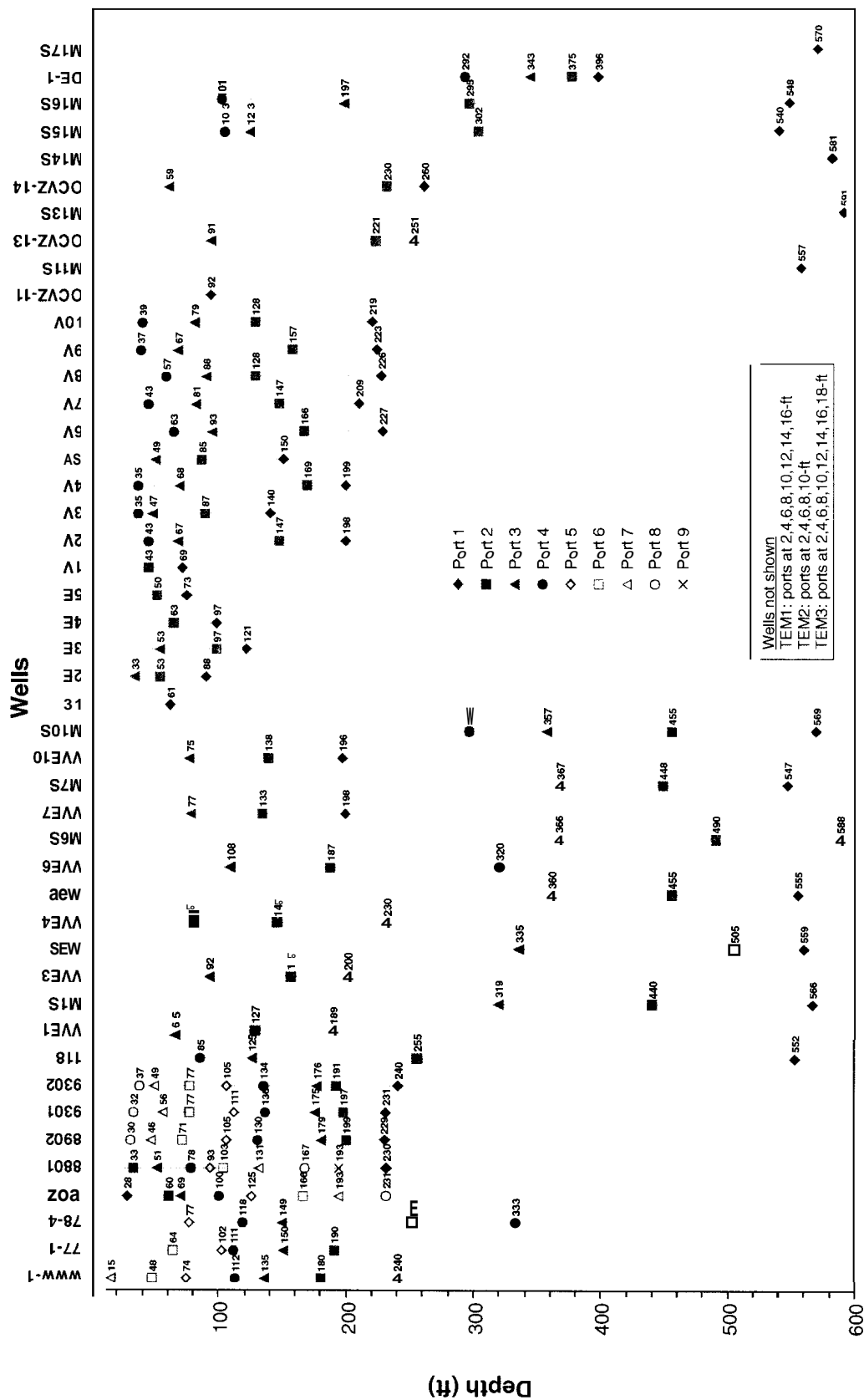


Figure 4-71. Vapor sampling port depths and numbers.

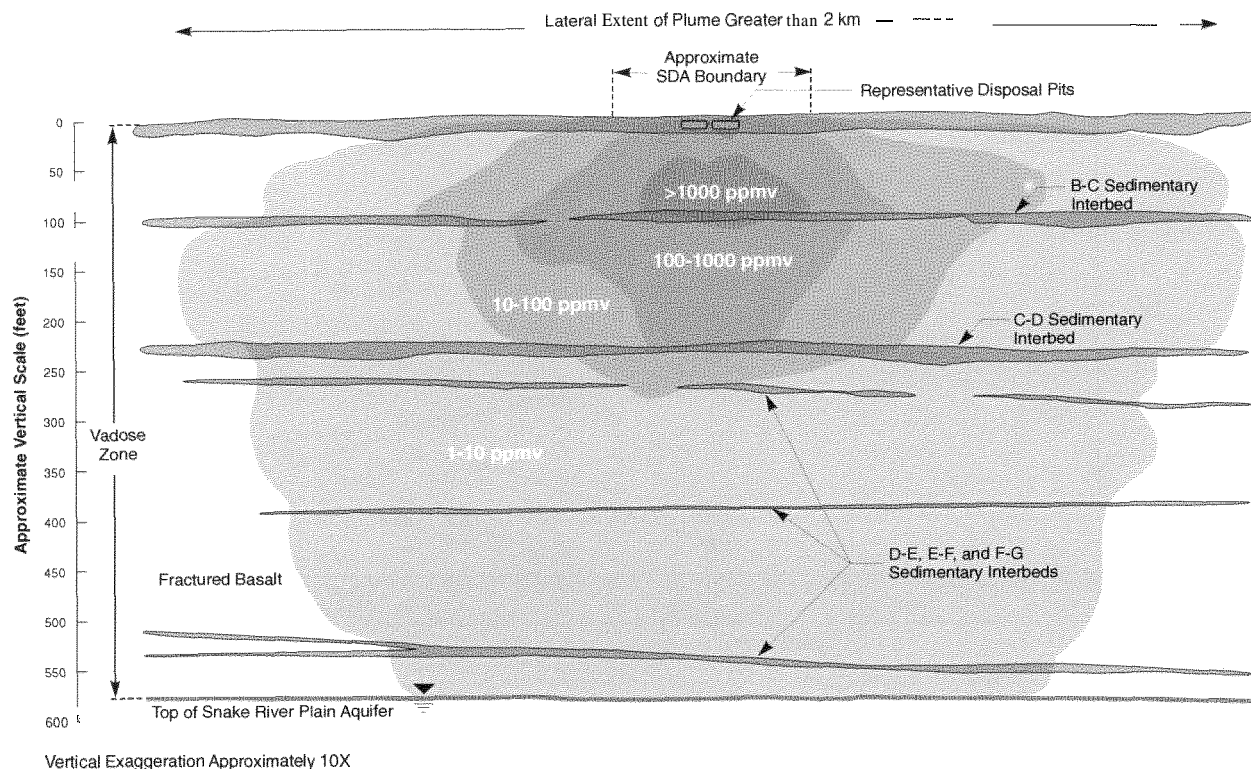


Figure 4-72. Conceptual drawing of the carbon tetrachloride soil gas plume prior to vapor vacuum extraction operations.

distance from the SDA. Carbon tetrachloride concentrations in wells only 250 m (820 ft) from the SDA boundary are approximately two orders of magnitude less than concentrations below source areas. Concentrations in the furthest wells from the SDA, OCVZ-11 and OCVZ-13, are less than 1 ppmv. Though Wells OCVZ-11 and OCVZ-13 were installed after 1996, it is improbable that the VVE system has influenced concentrations so far away.

Vertically, the CCl_4 contamination extends from land surface down to the water table. Figure 4-73 shows a time-averaged vertical concentration profile of CCl_4 prior to VVE operations for Wells 8801, 9301, and 9302, located near the center of the SDA. Concentrations increased with depth from near zero at land surface to several thousand ppmv above the B-C interbed. Concentrations decreased sharply across the B-C interbed down to several hundred ppmv. From just below the B-C interbed down to the C-D interbed, concentrations decreased from several hundred ppmv to a few hundred ppmv. Until recently, the concentrations below the C-D interbed inside the SDA were not known.

Figure 4-74 shows the soil gas concentration vertical profile for CCl_4 in the V- and VVE-series wells. As expected, the concentrations decrease with distance away from the 743 sludge source areas. The highest concentration in the V-series wells inside the SDA is less than 600 ppmv, and in the VVE-series wells outside the SDA the highest concentration is less than 80 ppmv. In the wells furthest away from the 743 sludge source areas (9V, 10V, VVE1, VVE3, VVE4, VVE6, and VVE7), the highest concentrations are located below the B-C interbed and in some cases, below the C-D interbed. This is likely the result of lateral migration of contaminated soil gas after it has migrated below the B-C interbed under the pit source areas. Also, contaminated soil gas above the B-C interbed will dissipate more rapidly as it migrates laterally because of surface volatilization and barometric pumping.

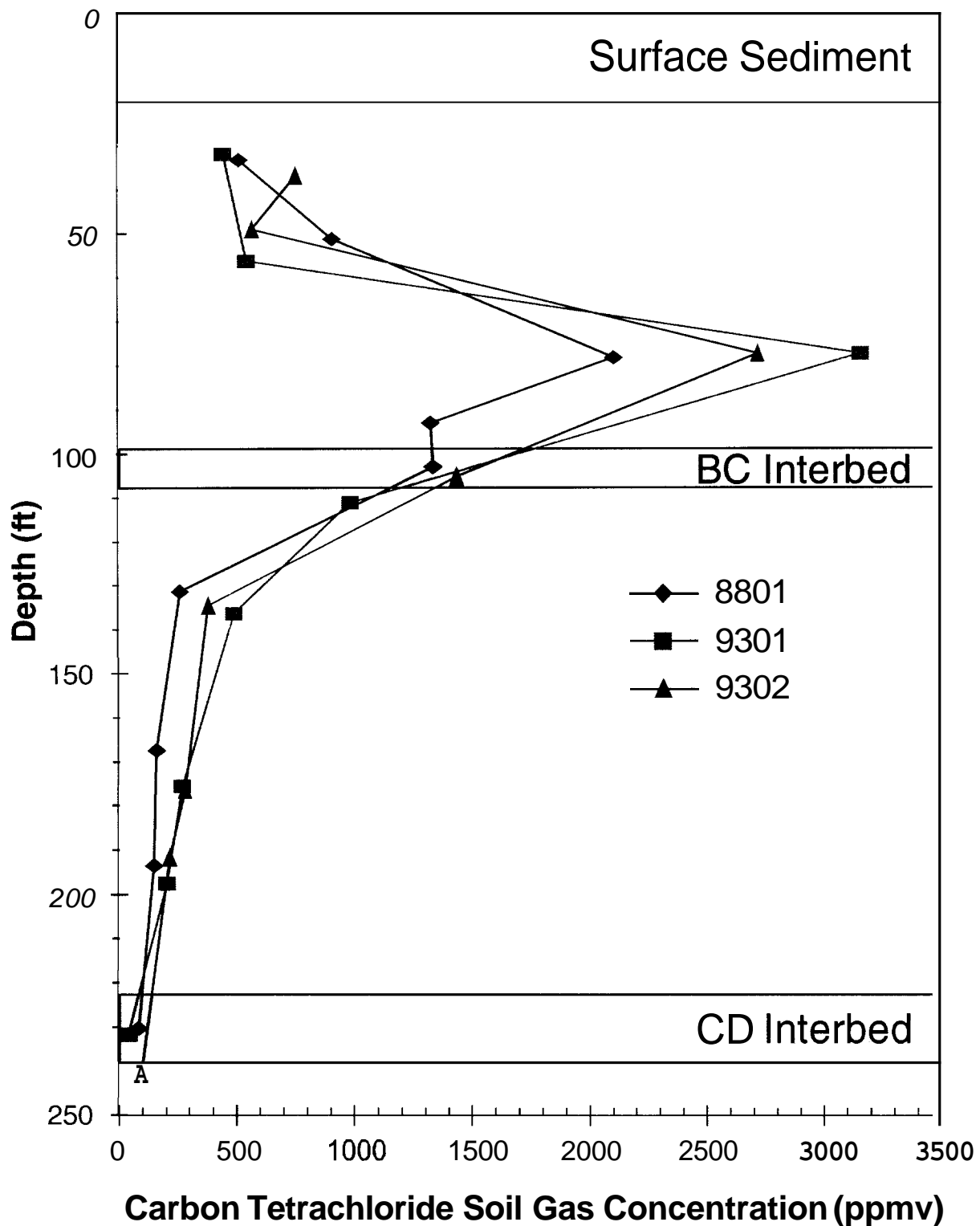


Figure 4-73. Profiles of carbon tetrachloride soil gas vertical concentrations for Wells 8801, 9301, and 9302, near the center of the Subsurface Disposal Area averaged over the period from April 1993 to October 1995, excluding data collected during the 1993 organic contamination in the vadose zone treatability study.

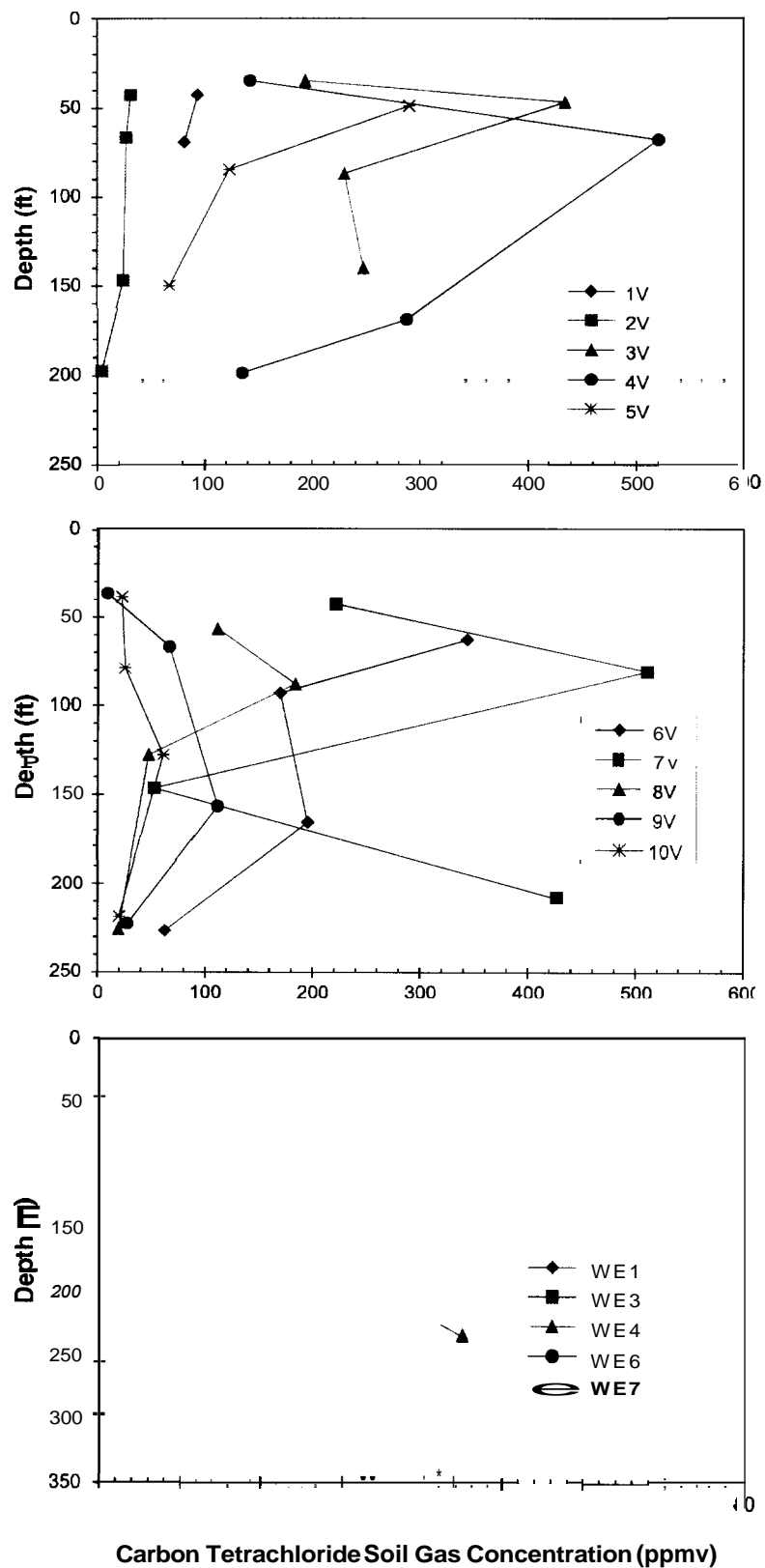


Figure 4-74. Profiles of carbon tetrachloride soil gas concentrations for V- and VVE-series wells averaged over the period from January 1995 to October 1995.

Since the startup of OCVZ operations in January 1996, soil gas concentrations have decreased markedly at many locations in response to the gas extraction. Figures 4-75 and 4-76 show the soil gas concentrations at two wells (8801 and 9301) near vapor extraction Well 8901D. Prior to 1996, the CCl_4 concentration at the 21-m (70-ft) depth (above the B-C interbed) was approximately 3,000 ppmv in these two wells. After extraction began, the concentration dropped to about 1,000 ppmv. At about the 40-m (130-ft) depth below the B-C interbed, the concentration dropped from about 600 ppmv before VVE operations to 100 ppmv after operations. Concentrations in the deeper ports, around 70 m (230 ft), appear to be unchanged by operations. In Well 9V (Figure 4-77), the initial drop in concentration was not so dramatic, probably because it is located farther away from an extraction well, but the decrease has been steady nonetheless. Even the deep gas port at 68 m (223 ft) shows a clear decline in concentrations.

Results similar to those shown in Figures 4-75, 4-76, and 4-77 have been observed at many of the soil gas monitoring well locations inside the SDA. This is evident from looking at Figure 4-78, which compares the results of soil gas concentrations at the 21-m (70-ft) depth at the beginning of OCVZ operations (January 4, 1996) with those measured after more than five years of operations (April 3, 2001). The figures were created by kriging the data from all ports in three dimensions and then taking a horizontal slice at the 21-m (70-ft) depth. Kriging takes into account the spatial relationship of a series of points, permitting interpolation within a three-dimensional matrix of points and estimation of additional data points. The figure shows concentrations in 2001 to be significantly less than they were five years ago, especially in the center of the SDA. However, the results may be misleading in that the 2001 data do not reflect an equilibrium condition. In a classic soil gas removal system, the subsurface concentrations are reduced and held to low levels when the system is operating. After the system is shut down, the subsurface concentrations rebound (increase) to an equilibrium condition dependent upon several geologic and contaminant-specific factors. The time required for the organics in the vadose zone to achieve full rebound has not been determined. The VVE system was shut down for a nine-week rebound period during the summer of 2000, but the data indicate that full rebound may not have occurred because subsurface concentrations were still increasing at some locations. Though individual VOC treatment units have been shutdown for longer than nine weeks, all VVE units in the system must be shutdown to determine rebound.

One other potentially misleading aspect of Figure 4-78 is that it shows low concentrations in the area around Pit 9 before OCVZ operations and currently. While this may be the case, data pertaining to the vicinity of Pit 9 are lacking. Concentrations are expected to be higher than shown when adjusted to inventory records, but no specific data either support or refute this hypothesis.

4.8.1.3.4 Perched Wafer Data—Only a small set of perched water data exists for the SDA because of the lack of perched water wells and the infrequent development of perched water in the existing wells. Carbon tetrachloride and other VOCs have been detected in samples from Wells USGS-92, 8802D, and D10 located inside the SDA. Sample depths and CCl_4 concentrations measured in perched water samples are shown in Table 4-130. The highest concentration (2,400 $\mu\text{g/L}$) was detected in Well USGS-92 in 1992. Prior to the commencement of OCVZ operations in 1996, concentrations in Well USGS-92 ranged from 1,200 to 2,400 $\mu\text{g/L}$. Since OCVZ began operations, the concentrations have ranged between 14 and 291 $\mu\text{g/L}$. Well USGS-92 is located near Well 7V, an OCVZ vapor extraction well. The time history of CCl_4 concentrations in perched water in Wells USGS-92 and 8802D is shown in Figure 4-79.

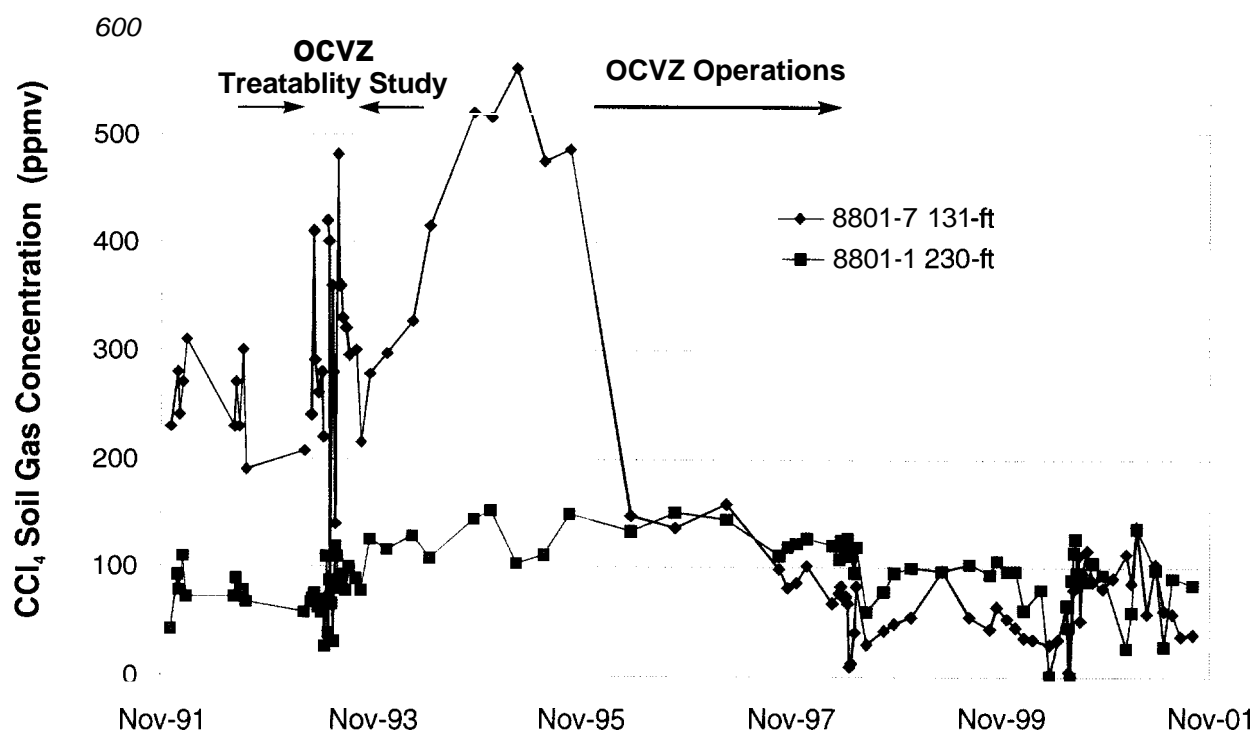
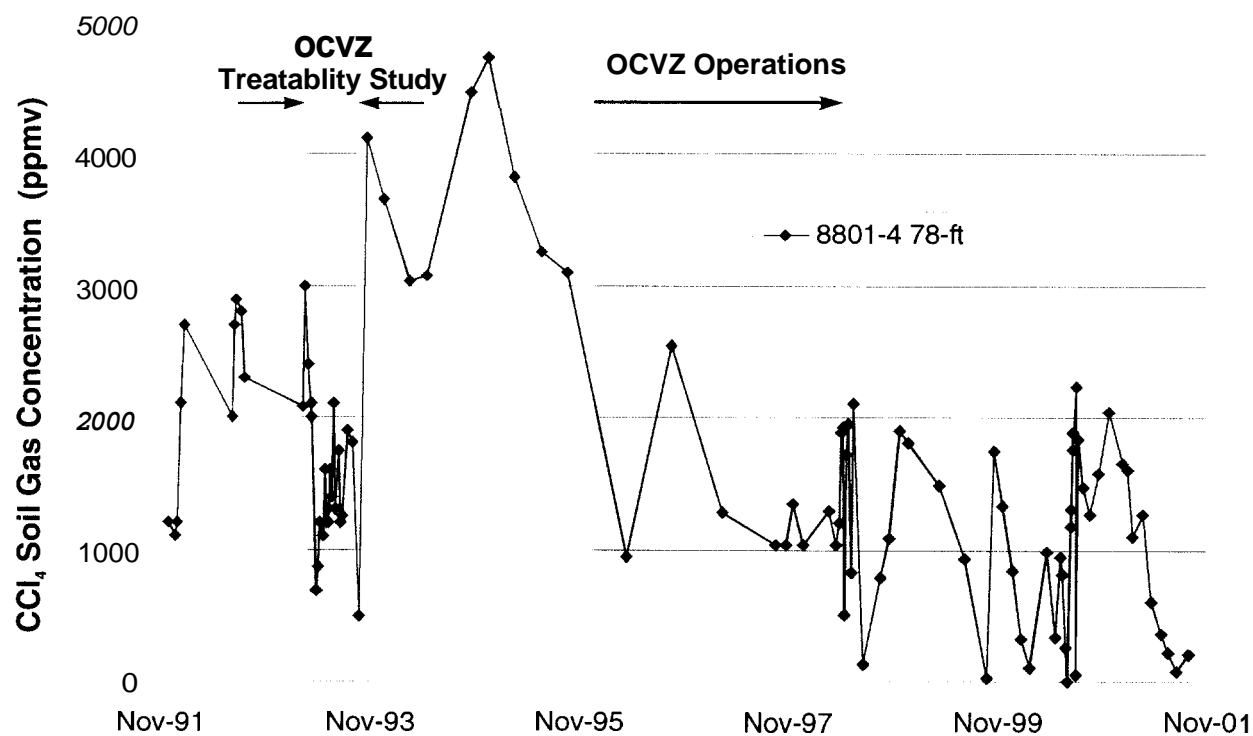


Figure 4-75. Carbon tetrachloride soil gas concentration time history for selected ports in Well 8801.

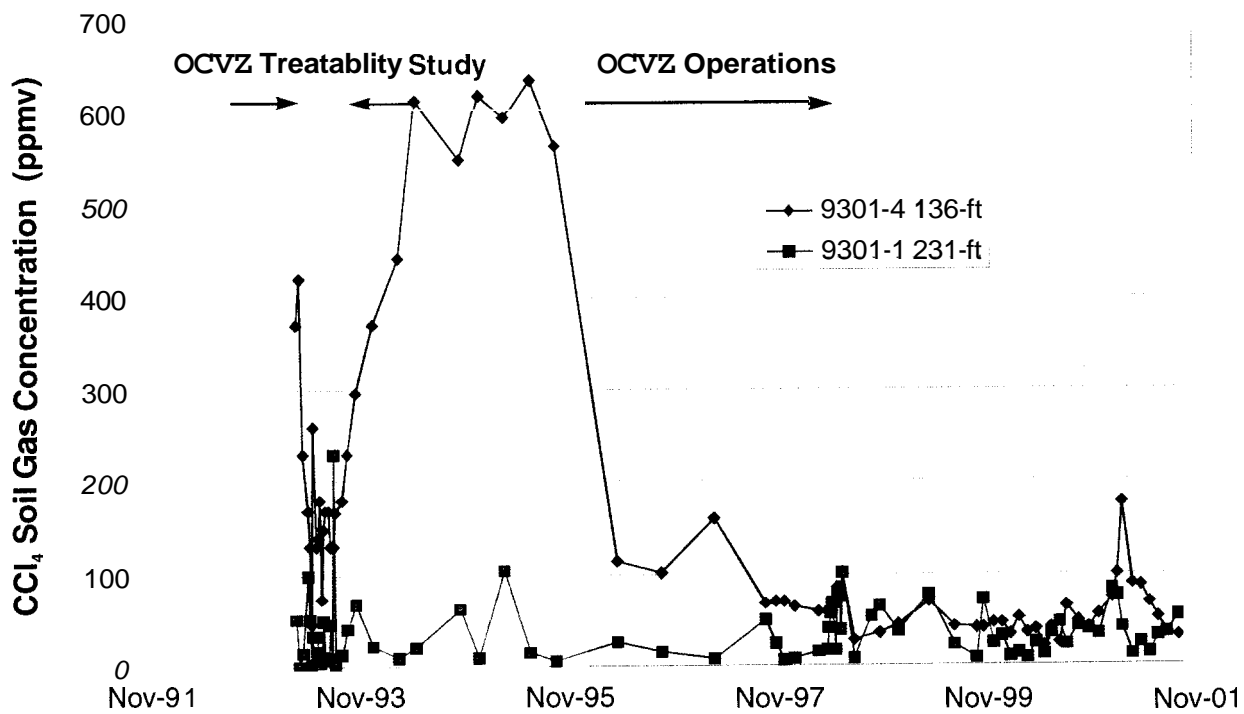
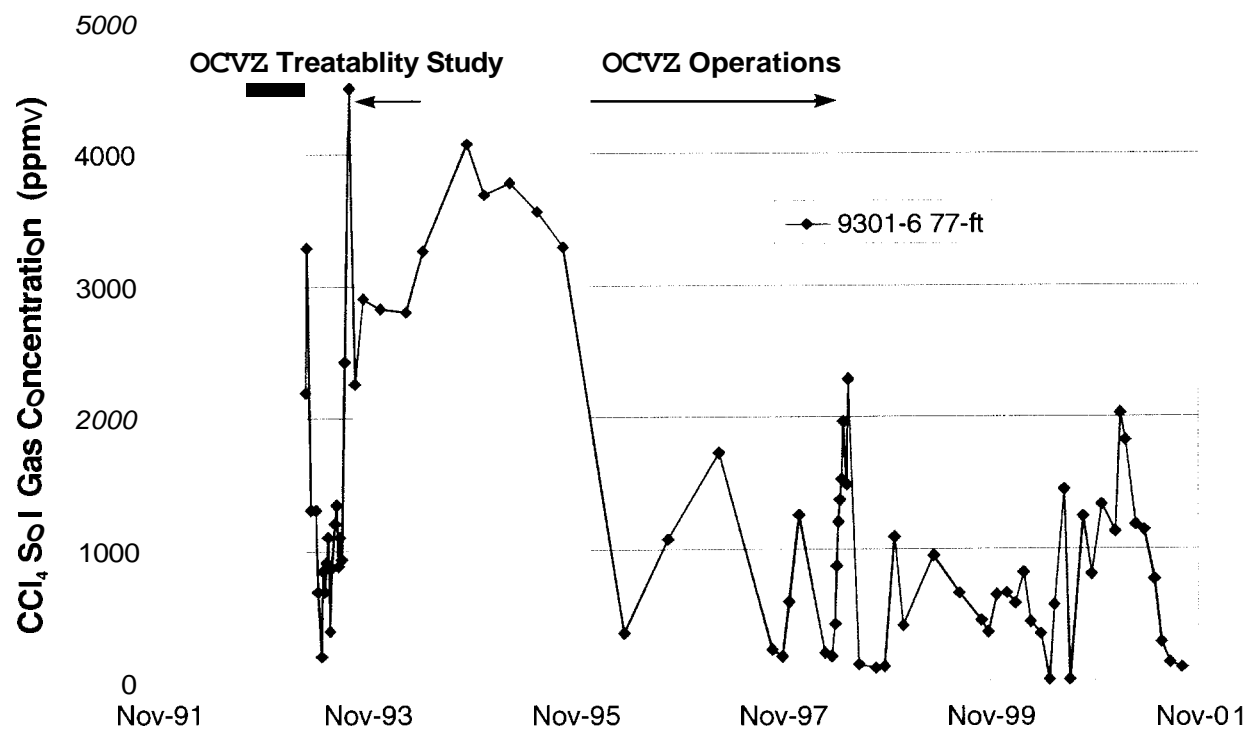


Figure 4-76. Carbon tetrachloride soil gas concentration time history for selected ports in Well 9301.

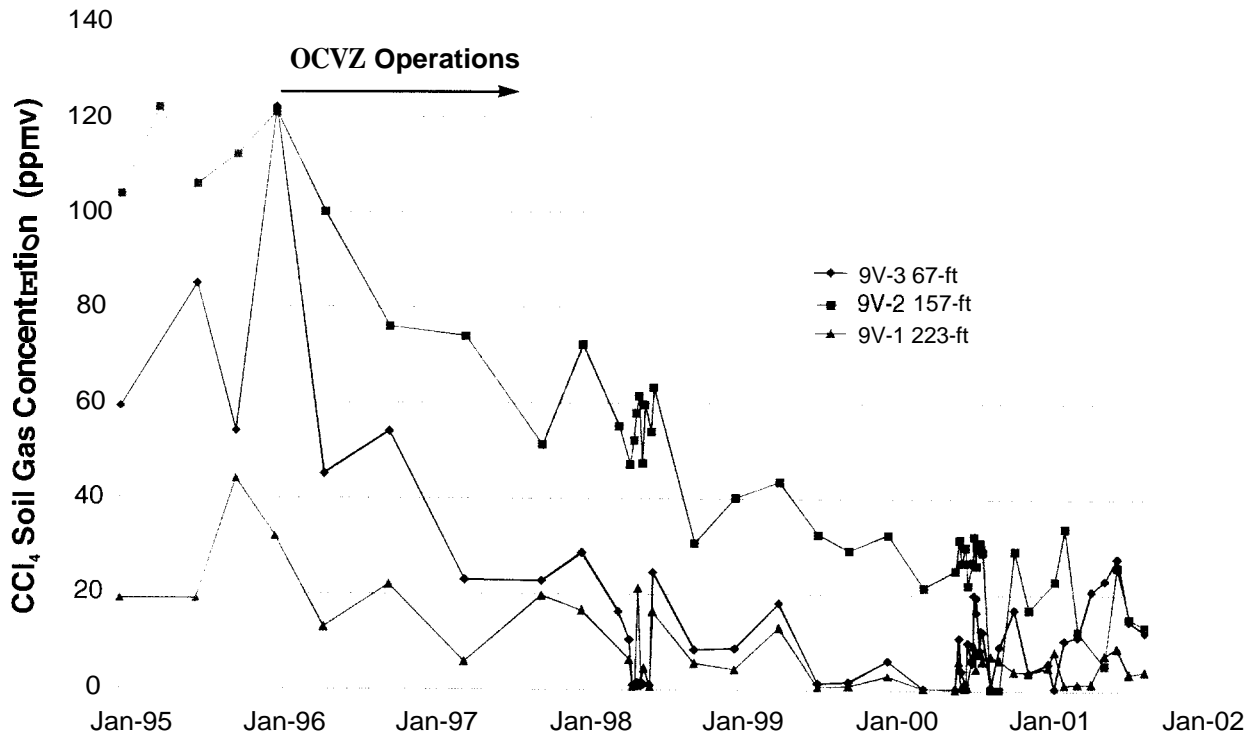
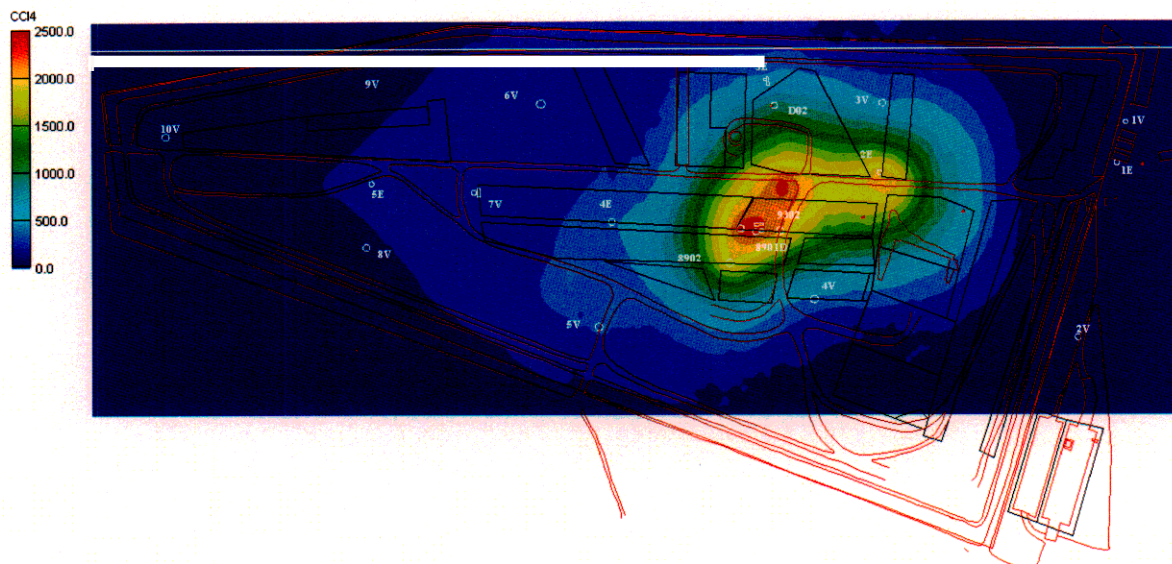


Figure 4-77. Carbon tetrachloride soil gas concentration time history for selected ports in Well 9V.

Carbon tetrachloride concentrations in the vadose zone at the SDA for January 4, 1996 in ppmv at 70 ft.



Carbon tetrachloride concentrations in the vadose zone at the SDA for April 3, 2001 in ppmv at 70 ft.

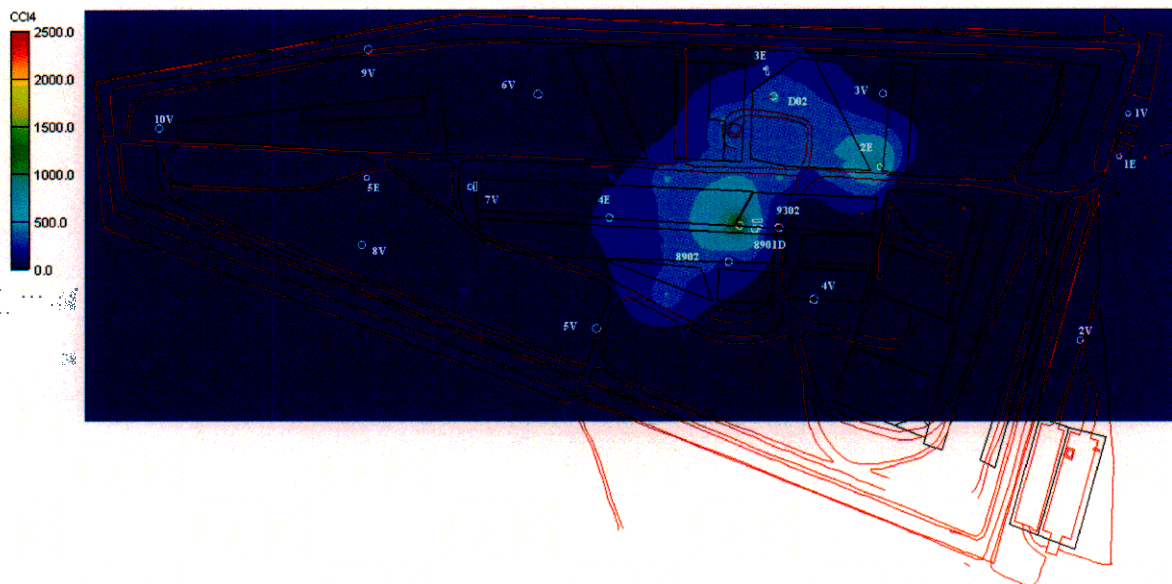


Figure 4-78. Comparison of initial carbon tetrachloride concentrations at the 21-m (70-ft) depth with concentrations after 5 years of vapor vacuum extraction,